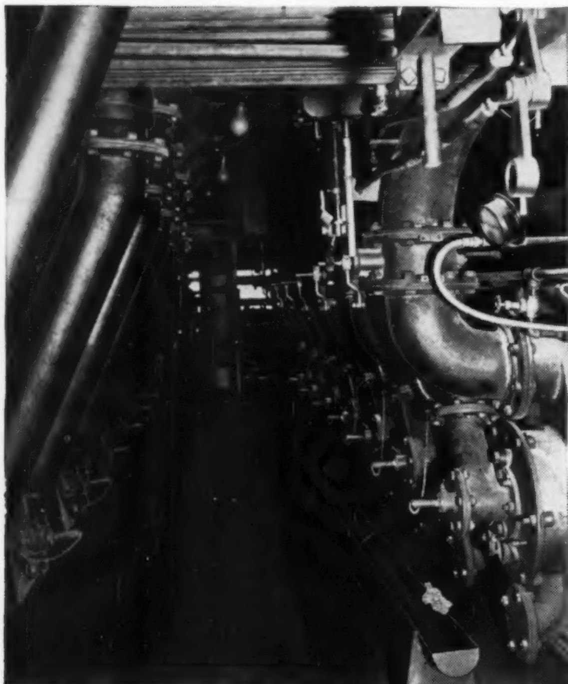
MECHANICAL ENGINEERING

AUGUST 1944

SIMPLIFIED FIRING FOR METALLURGICAL FURNACES . . .



SAVES FUEL AND SPACE INCREASES PRODUCTION

Dependable and economical pulverized-coal firing of multiple metallurgical furnaces requires only ONE pulverizing unit with the B&W Direct-Firing Circulating System. Thus, many substantial savings on installation, production, and maintenance over other methods of firing are obtained.

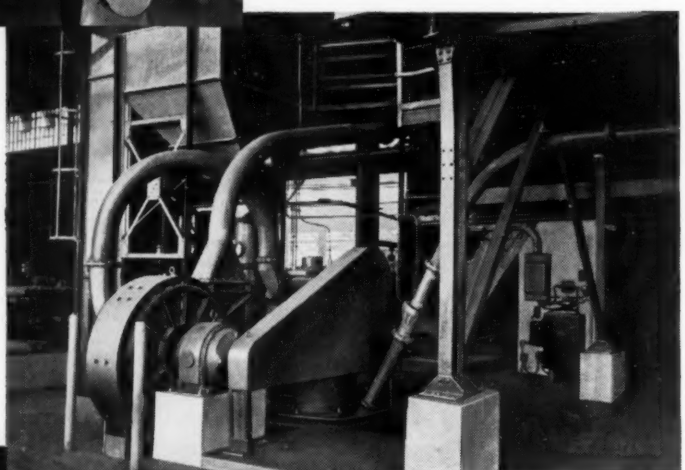
Simplicity of the system eliminates multiple piping and coal handling equipment, saves floor space around the furnaces, and eliminates interference with product handling at the furnaces.

Adequate fuel distribution and capacity of this system on single or multiple furnaces is assured by automatic control of coal-to-air ratio, by selection of the proper sizes of pulverizers, fan, burners, and distributing line.

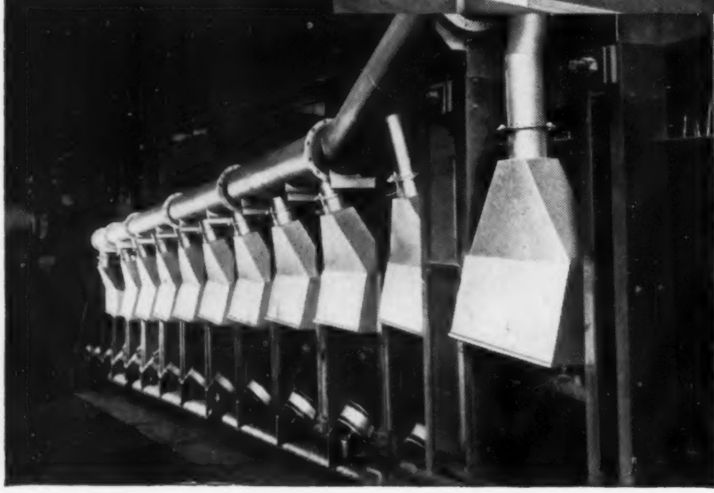
The operating ease and flexibility of this system, as well as its cost-saving features, have been clearly demonstrated by the performance of existing installations.

A few of the advantages of the B&W Direct-Firing Circulating System are illustrated here. More detailed information is contained in Bulletin 3-333. Send for your copy.

1 Multiple burner installation on single large furnace of double heating zone type. Burners at right firing heating zone and first group of burners in the circuit. Burners at left fire soaking zone and last group in the same circuit, which also serves a second large furnace of the double heating zone type.



2 The single, compact pulverizer unit can be conveniently located away from the furnaces, keeping floor space at furnaces clear for product-handling operations.



3 Hoods and ash sluicing systems eliminate dust nuisance ordinarily resulting from firing pulverized coal in heating furnaces with inadequate draft provision.

BABCOCK & WILCOX

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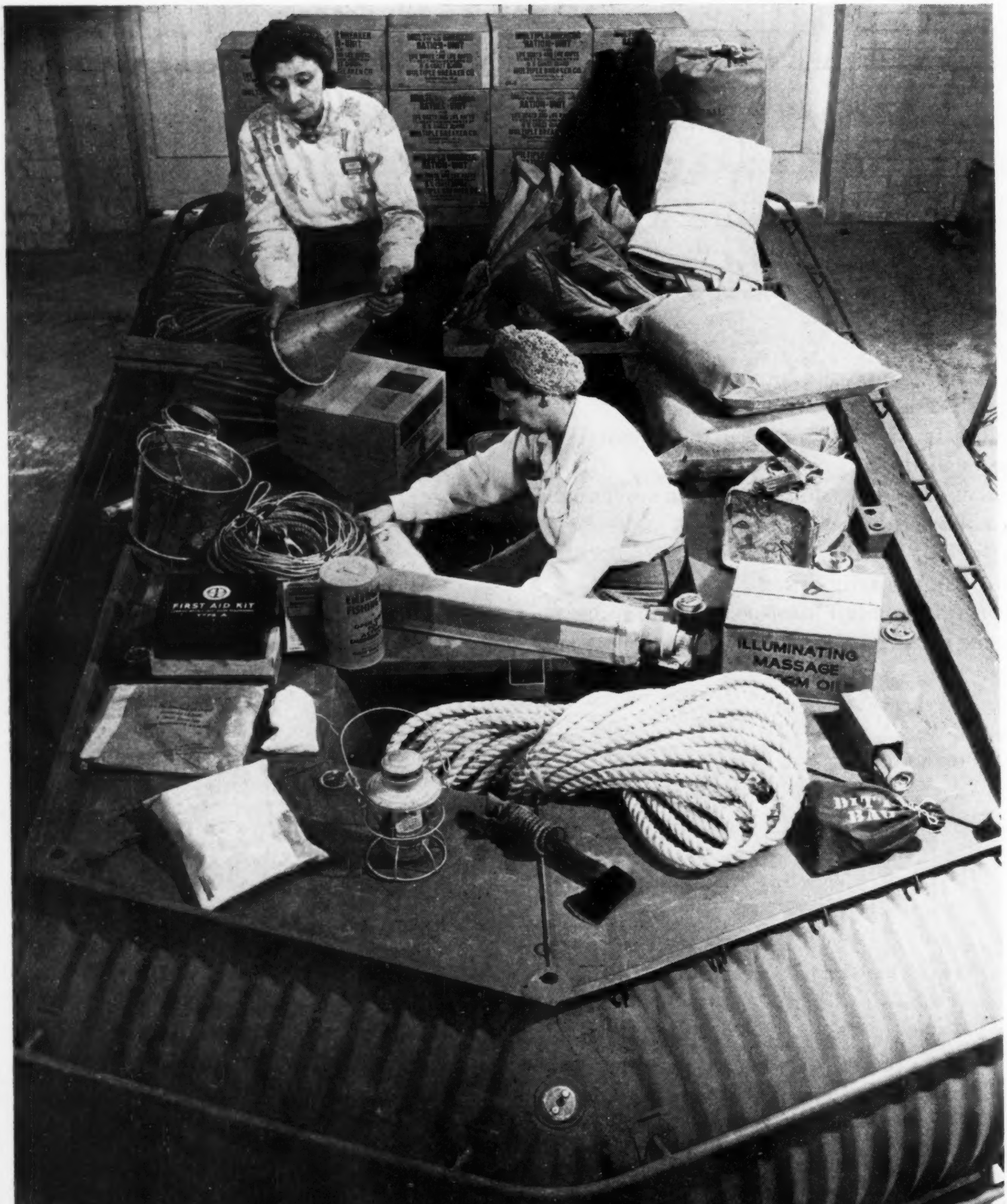

Metal Life Raft

(When a raft leaves the plant of the Weber Showcase Company it carries 1055 pounds of equipment, shown being loaded here. All these items are carried in waterproof compartments amidship, each available from both top and bottom.)

Volume 66
No. 8

MECHANICAL ENGINEERING

August
1944

GEORGE A. STETSON, *Editor*

M.I.T. Book Reviews

DURING the depression of the 1930's, engineers, in common with others, had their attention directed very forcefully to the economic factors which influence society, business, industry, and government. Individually and collectively they discussed the problems and principles involved and attempted to offer solutions. The American Society of Mechanical Engineers, in its meetings and publications, afforded forums for these discussions, and a considerable number of articles, written by engineers, economists, and others, were published in MECHANICAL ENGINEERING.

The experience led the Committee on Publications to suggest to the A.S.M.E. Management Division that a continuing thread of discussion of economic subjects relating to the interests of engineers be made a feature of the editorial service of MECHANICAL ENGINEERING. Acting upon this suggestion the Management Division enlisted the interest and aid of Prof. Ralph E. Freeman, of the Department of Economics and Social Science, Massachusetts Institute of Technology, in preparing reviews of books on economic subjects for publication in MECHANICAL ENGINEERING.

Beginning with the April, 1935, issue, and continuing through May, 1944, these reviews, written by Professor Freeman and his colleagues, have appeared every month, almost without a break. They have been exceptionally well received and thoroughly appreciated by readers of MECHANICAL ENGINEERING. Moreover, from an administrative point of view, the arrangement has been a source of satisfaction and admiration. So faithfully did Professor Freeman perform this voluntary service to the Society that the editorial staff soon had the utmost confidence that the review would not only be of high quality but that it would be received without fail on the first of every month.

Pressure of war conditions and the manpower shortage have forced Professor Freeman and his colleagues to reduce the frequency of their reviews, although it is hoped that the reviews will continue on a bimonthly basis.

On April 19, 1944, the Executive Committee of the A.S.M.E. Management Division inserted the following statement in its minutes:

"The Executive Committee of the Management Division is deeply appreciative of the timely and thoughtful reviews of important contributions to the literature of economics which have been prepared by the staff of the Massachusetts Institute of Technology. We feel that these reviews have contributed materially to the broadening of the view of the mechanical engineer. We appreciate the fact that current conditions may require a reduction in the frequency of these reviews. We would urge that these reviews be retained on a bimonthly basis, the monthly reviews to be resumed when conditions permit."

In consideration of the foregoing facts the Committee on Publications voted: "To express its sincere appreciation and sense of deep gratitude to Prof. Ralph E. Freeman, of the Department of Economics and Social Science, Massachusetts Institute of Technology, and to his colleagues for their contributions of reviews of books on economic subjects which have materially broadened the view of readers of MECHANICAL ENGINEERING; for their faithful performance, month by month over a period extending from April, 1935, to May, 1944, of a task voluntarily assumed and without recompense; and for the extraordinary promptness with which these contributions were submitted."

At a meeting on June 18 the Executive Committee of the Society entered upon its minutes the vote of the Committee on Publications to which it added "its grateful appreciation and thanks for the splendid contribution to the engineering profession."

Postwar Problems

SOME observations on the experiences of the Westinghouse Electric and Manufacturing Company in converting from peacetime to wartime production and on postwar problems were made in an address delivered by Frank D. Newbury at a luncheon in Pittsburgh during the 1944 A.S.M.E. Semi-Annual Meeting. The text of the address appears in this issue. It will be read with interest and profit by anyone who has given thought to postwar problems. By and large, engineers connected with large manufacturing organizations will find much to commend in Mr. Newbury's statements.

Mr. Newbury naturally bases his observations on Westinghouse experience. He quotes from the conclusions of the Westinghouse Economic Research Committee. These facts increase rather than decrease the value of the address. Such data as are quoted are real, although they may not be typical of all American industry. Moreover, the views on postwar problems are obviously more than the personal opinions of an individual; they reflect, to some extent at least, the results of studies made by a committee of the manufacturer. Best of all, the statements come from a man "on the firing line," and not from an academic theorist.

The temptation to quote liberally from Mr. Newbury's address is considerable. Without overlooking the fact that "we are facing a greater variety of new conditions with less information," the author says that "postwar planning is no new problem; it is no different except in degree and in difficulty from the long-term planning

that successful businessmen are doing continuously. We should talk more about long-term planning and less about postwar."

It is heartening to read such passages as: "However much industry and the public generally may desire to avoid the sufferings and losses of extreme unemployment, full employment, in the end, will depend upon the confidence of the public and of industry in the immediate future and their consequent willingness to spend their money. . . . It is the people who in the end must provide the means of their own employment." These are truisms which are too easily forgotten by wishful thinkers who hope to be saved from disaster by miracles.

Modern industry is a complex mechanism, Mr. Newbury declares, and many influential people do not understand how industrial organizations do their work and what is necessary to keep them in good health and activity. This places upon men in industry the responsibility "to tell industry's story." "Right now," he continues, "some business leaders . . . are giving the public the contrary impression that industry can, by its own planning and of its own volition, provide full employment; and that if industry fails, the Federal Government will step in and do the job. We must find the understanding, the ability, and the courage to tell the people that, at bottom, industry is only their servant and can only do their bidding."

Postwar costs and postwar prices are treated with a realism based on experience. Here again it is necessary to understand what is involved and to get others to understand also. "In the transition from war production to more normal peacetime conditions, manufacturers will find themselves with high wage and salary rates, a management and supervisory organization that is production- and quality-minded, but still callous with the scars of wartime extravagance and with selling prices frozen at prewar levels. Manufacturers will need all the help they can get from better management, better engineering, better equipment and methods, and above all the help from a wise labor-union policy, if industry is going to survive in a healthy condition and provide jobs during this difficult transition time."

These scattered excerpts may serve to compel a reading of the complete address, which has a realistic and sobering quality and contains a challenge for engineers in industry to put forth their most skillful and intelligent efforts when "postwar" problems become the day's work.

Southern Research Institute

ONE of the gratifying experiences of attending engineering meetings in the South year after year is to witness the growing interest which engineers and businessmen show in the development of the resources of that important section of the nation. Combined with rich resources in agricultural products and raw materials, the South possesses the available labor, power, and climatic conditions favorable for industrial development. By increasing the proportion of these agricultural products and raw materials which are processed and manufactured into finished goods within the region itself, and discovering new materials, new uses for materials, and new ways of preparing them for the market, the South will provide greater employment for its people, raise their standard of living, and thus greatly strengthen its economic condition.

In addition to increasing its industrial activity the South has been making progress in research upon which economic advancement depends. The great universities of the Southern States, certain trade associations and individual enterprises, as well as other public agencies, among which the T.V.A. is conspicuous, have been and are making notable strides in research. Among these the recently organized Southern Research Institute, formerly the Alabama Research Institute, will be watched hopefully by engineers and friends of research progress.

The Southern Research Institute, according to a brochure recently received, is "dedicated to the economic advancement of the southern region." It was organized "to direct scientific research to the end that new and improved products shall be created; to provide research facilities to existing business establishments which do not have the equipment and business personnel to undertake the solution of their own technological problems; and to afford facilities to those industries which, although having well-equipped laboratories of their own, find it advantageous from time to time to have certain types of work done in an atmosphere removed from all direct contact with their own production problems."

Patterned after the Mellon Institute, the Southern Research Institute plans to be self-supporting out of its own earnings and resources. Any person, firm, association, or corporation interested in scientific research may become a member of the Institute. The board of trustees is elected at the annual meeting of the membership, "each member in good standing having one vote, regardless of the amount he may have contributed to the initial capital of the Institute."

Thomas W. Martin, well known to engineers as the president of the Alabama Power Company, is present chairman of the Board of Trustees, on which serve industrialists, bankers, engineers, and businessmen. Under such leadership and with a fair portion of its capital funds already subscribed, the Institute has bright prospects of fulfilling the purposes for which it has been founded.

A.S.M.E. Membership List

IN July the A.S.M.E. Membership List was issued to members of the Society. Nearly two years and a half have elapsed since the publication of the most recent former list. During that period the membership has grown rapidly. Changes of address and position of members have been many because of the war.

Because of the paper shortage the usual geographical list of members has been omitted in the 1944 edition, as has also the list of student members. The index of consulting engineers has been retained. A.S.M.E. Council and Committee Personnel, formerly a part of the Membership List, was issued separately in February.

The length of the list of members should be gratifying to all members of the Society. It represents a virile growing organization of the nation's most important mechanical engineers.

POSTWAR PROBLEMS

By FRANK D. NEWBURY

VICE-PRESIDENT, WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY, EAST PITTSBURGH, PA. MEMBER A.S.M.E.

BEFORE we discuss the future, it may be worth while to remind ourselves of the strange road we have been traveling during the past three or four years. This is no simple task; we have adapted our thinking and behavior to this highly abnormal war world so that, little by little, it has become our normal world. It will be difficult to retrace our steps to postwar sanity.

For purposes of this presentation, I will use Westinghouse figures and experience simply because I know them at firsthand, but our experiences differ from others only in details, and I think we may look at them as typical of machinery manufacturers generally.

In 1940, when the "defense program" started, but before it had any considerable effect on production, Westinghouse had the biggest year in its history; 1940 was the first year, in fact, that exceeded 1929. I mention this only to point out the highly important consequence, that when the nation really became alarmed, realized its own direct interest in the European struggle, and turned to industry for military goods, it found that many manufacturers were already carrying the heaviest load in their history.

TRANSITION TO WAR PRODUCTION

The first problem in many companies was to overcome the peacetime, business-as-usual attitude of its own operating people. This applied particularly to heavy-machinery manufacturers; because automobile and other manufacturers of durable consumer goods were then in a different situation.

This change in organization attitude was accomplished in Westinghouse by setting up an entirely separate group to handle new military products—mainly ordnance. We called this the Emergency Products Division, and it was a headquarters combined sales and engineering group whose duty it was to locate ordnance work that best suited Westinghouse experience and facilities and to find such facilities within the company's twenty-odd major plants. This Emergency Products Division had nothing to do with negotiations and contracts for familiar electrical goods; we handled only the new ordnance items. Among our earliest contracts were naval gun mounts, tank-gun stabilizers, hydraulic power units for Army guns, bomb fuses, binoculars, and on into many other strange fields.

Westinghouse found one of its major contributions to the war program in the manufacture of the larger sizes of ordnance equipment for the Navy, undertaking for the Navy the construction and operation of two new Naval Ordnance Plants in the fall of 1940, and a third related Naval Ordnance Plant which was taken over for operation in the fall of 1943. These three plants represent an investment of government funds of over $70,000,000 and currently employ over 15,000 people.

The Emergency Products Division had a single purpose and responsibility, i.e., to place the available facilities of the company (and this applied to management even more than to physical properties) at the disposal of the Government, and to find out how this could be done most effectively and in the shortest possible time. Whatever success this organization has had is, I believe, largely due to this singleness of purpose, divorced from the company's usual operations.

Contributed by the Management Division and presented at the Semi-Annual Meeting, Pittsburgh, Pa., June 19–22, 1944, of The American Society of Mechanical Engineers.

PROBLEMS OF VAST EXPANSION IN PERSONNEL

On December 31, 1939, Westinghouse had approximately 46,000 employees, and the management and the supervisory forces adequate for an organization of this size. Four years later, on December 31, 1943, this figure of 46,000 had grown to 115,000, an increase of 150 per cent, with management and supervision spread dangerously thin.

Only those who have been close to production problems during this period can realize the headaches and the tremendous cost of this rapid expansion. Our problems have been small compared with those of many companies where employment has increased from a few hundred or a few thousand to ten or twenty times these figures. There are a number of companies that have lost more employees to Selective Service than these companies employed in 1939.

Five of our major operating divisions spent nearly $9,000,000 in direct labor costs, applied to training new employees, during these four years. This was $557 for each employee gained over the four-year period.

In new plants this direct labor cost of training new employees, starting outside and continuing inside the new plant, has varied from $800 to $1200 for each new employee remaining at the end of the training period.

This rapid increase in number of employees has required a corresponding increase in foremen and other supervisory and technical personnel, most of whom moved up from the ranks. In one new plant having 9000 employees, we will spend $25,000 in direct costs of foremen-training classes. It is vitally important to train these new foremen, to make them a part of management, particularly in the field of labor relations. If this is done well, there is little to fear that foremen will change their primary allegiance from management to a foreman's union.

An over-all picture of what war production has done to Westinghouse can be seen in the following figures:

	Per cent
Increase in owned floor space	12
Increase by reason of leased floor space	32
Increase in total floor space	44
Increase in original cost of owned facilities, land, buildings, equipment	30
Increase in number of employees	150
Increase in dollar value of annual production (including Naval Ordnance Plants)	350

These figures considered superficially show some surprising results: Increase in dollar value of output (with the same or lower price level), over seven times the increase in floor space, and increase in output over twice the increase in number of employees.

We have changed our ideas, and I am sure many others have also, as to prewar plant capacity because of this greatly increased output from old facilities. Some reasons for this are the use of less desirable idle space; crowding more equipment and more people into a given working space; increasing the number of shifts and the hours per shift; subcontracting more work; and the advantages of larger production lots, fewer varieties of product, and different kinds of product. All of these factors, except the last, have increased unit costs and will not be continued, at least to the same extent, after the war emergency ends; but this increased capacity, from old facilities, largely unrealized before the war, has been a very fortunate development of war experience.

I believe most individuals will agree that increase in labor efficiency and effort is not one of the important reasons for increased output per worker. On the contrary, one of the headaches that management has had to overcome, as best it could, has been the lower average skill and experience of the working force, and the mistaken union policy directed against any move by management that could be labeled a "speed-up" or "excessive" effort, or "excessive" efficiency of individual workers; but which management honestly believes is only a "reasonable and economical use of labor."

Some observers have jumped to the conclusion that this considerable increase in output per worker does represent an advance in individual worker effort and efficiency, as compared with prewar experience, and that this is a factor which will mean lower postwar labor requirements and employment for a given national production. On the contrary, I believe that, when the best of the present working force returns to civilian work, their output will be no greater than when they left off their old jobs in 1941 or 1942, except as output per man-hour may be increased by normal progress in new equipment and new methods.

It is a fact that man-hour requirements for ships, for aircraft, and many other military products have been greatly reduced over the past two years; but this improvement should be measured against the terribly inefficient conditions of 1941-1942 and not against the performance of prewar experienced labor.

Westinghouse has been slow to start any organized postwar planning. This subject began to be discussed as a public question early in 1942. We thought it premature then; and it is still early enough in our opinion; if you ask the Army, it is still too early.

We have also been skeptical as to the wisdom of assuming any fixed value of postwar gross national production as a measure of postwar demand—say 150 billions—and urging manufacturers to plan on this over-all basis. We prefer to build our own estimates from the bottom up, rather than from the top down.

Westinghouse has now set up a Postwar Planning and Development Committee composed of six vice-presidents representing responsibility for general management, sales, engineering, manufacturing, and finance. This committee is a headquarters-staff group, and its function is to present the general problems to the operating divisions, and to stimulate their study. Each operating division and subsidiary company is responsible for its own planning and, particularly, all product development; the headquarters committee expects only to stimulate and guide this work.

Now for some of our postwar conclusions. In order to keep this presentation within reasonable bounds, I will limit the discussion to the following subjects:

1 Postwar business volume and employment.
2 Manufacturing costs and market prices.

POSTWAR BUSINESS VOLUME

Postwar planning is no new problem; it is no different, except in degree and in difficulty, from the long-term planning that successful businessmen are doing continuously. We should talk more about long-term planning and less about postwar. We are, it is true, facing a greater variety of new conditions and with less information which makes this planning just now more difficult; but, on the other hand, a highly favorable fact for the nation is that everyone realizes that conditions following the war will be different, and people will be mentally prepared for change.

Each kind of product, each customer group, and each market area has its past history, its war experience, and its postwar prospects. As always, these should be studied by familiar market-research methods. Separately, and in addition to this individual-product approach, each large company has its own history and experience through which it has developed an individuality and a composite character that can serve as an additional guide to its future prospects.

We have approached our own estimates of postwar business by both of these roads. Each operating division has been encouraged to make its own forecasts of business volume and employment by studies of individual products and markets. The company, as a unit, acting through its headquarters Economic Research Committee, has made a consolidated company forecast which has been based upon past company trends and experience, and correlated with other guesses regarding postwar Federal Reserve Index, steel production, electric-power production, price levels, and other significant factors. The Economic Research Committee also is charged with the important task of watching developments of these general economic factors, correlating this information with the company's prospects, and comparing our own guesses with the opinions of other industrial and government economists.

One factor that is very difficult to evaluate in the individual-product approach is the effect of new products and new markets on company growth. This has always been an important factor in the electrical field, and the integrated company approach takes this into account in some fashion merely by extending past growth trends.

Our over-all guess of maximum postwar company sales is 60 per cent of the current 1944 billings; this may appear low, but it is also 175 per cent of the maximum prewar production and billings the company has ever experienced.

These figures, characterized only as "postwar," represent our estimate of the maximum years' billings during a period of several years following the end of the war. We look forward to a continuation of those year-to-year fluctuations in the volume of business, which we know as the business cycle, and we see no new factor strong enough to level them off, although we hope and expect their recent violence can be reduced. The efforts of the Government to this end during the 1930's increased these fluctuations rather than otherwise, because of wrong timing, particularly in the 1936 bonus payments, and the chances are that any other group of experts, controlled by political expediency, would have no better luck. We have also had a striking example, during the war, of the unprecedented cost, in taxation and debt, required to provide for full employment by Government spending.

POSTWAR EMPLOYMENT

Different lines of products will, of course, have quite different postwar prospects. There is general agreement that consumers' durable goods such as automobiles and electric refrigerators, will enjoy the most favorable situations. Certain classes of capital goods will suffer the most. Consequently, there are many different postwar employment problems—and each kind of business has its own.

Consumers' durable-goods industries will have a difficult problem in the reconversion of facilities, but once this has been accomplished these industries will be able to provide employment for all or more than those employed during the war. An example, in our own company, is found in a plant for the manufacture of refrigerator cabinets, ranges, washing machines, and smaller home appliances. This plant reached its maximum prewar employment in July, 1941, when 5000 people were employed. The lowest monthly employment during 1942 dropped to 1500 employees as the manufacture of civilian goods declined and stopped and increased to 4400 per month during 1943 as new military products were started. Postwar employment in this plant is expected to reach an average figure of 6000 per month within a reasonable time following the beginning of unrestricted manufacture of home appliances.

Companies and plants engaged in the manufacture of heavy industrial machinery, machine tools, and power-plant equipment face a less certain future. Many of these plants have ex-

panded employment and output several times since 1940, and cannot forecast any such scale of operations following the end of the war. Plants of this kind will undoubtedly reduce the number of employees, the average weekly hours, and the extent of multiple-shift operations. One of our heavy-machinery divisions anticipates a reduction in employment from 14,000 to 3000 or 5000.

Much has been written about the necessity for full employment after the war. However much industry and the public generally may desire to avoid the sufferings and losses of extreme unemployment, full employment, in the end, will depend upon the confidence of the public and of industry in the immediate future and their consequent willingness to spend their money. There will be plenty of money to spend; you can pick your own figures as to private savings up to 80 billions; but what may be lacking is the willingness and confidence to spend.

Modern industry is a highly complex mechanism; jobs in industry are made by the aggregate decisions of businessmen to expand facilities and by consumers to buy goods. We have never had prosperous times without both capital expenditures and consumer expenditures in large volume. Jobs are made in the long run by these private expenditures, and whether we have reasonably full and continuous employment after the war depends primarily upon the ability and willingness of people—as businessmen and as consumers—to buy. In the United States only 20 per cent of the people depend upon farming for their livelihood. Before the war, it was 40 per cent in England; 60 per cent in Germany; 80 per cent in Russia. There may be lack of cash income in farming, but never lack of employment.

The United States, because so small a part of its people live on farms, is more vulnerable to mass unemployment than any other industrial country; we are, without intending any such thing, carrying on an experiment that no other country has even attempted. Government can do much through wise tax policy and through encouragement of private enterprise, and management and labor can help by full co-operation, low-production costs, and a low-price policy, but it is the people who, in the end, must provide the means for their own employment.

This idea is so simple and so fundamental that one is bewildered to discover how frequently it is misunderstood. I believe the real difficulty is that many influential people outside of industry do not understand how industrial organizations do their work, and what is necessary to keep them in good health and activity; witness the recent proposal by Secretary Ickes that returning soldiers be given the ownership of government war plants, as if that would accomplish anything.

I believe we all have a responsibility here, to tell industry's story, to teach the public the nature of industrial organization, its limitations and its dangers, as well as its virtues. Right now, some business leaders, who should know better, are giving the public the contrary impression that industry can, by its own planning and of its own volition, provide full employment; and that if private industry fails the Federal Government will step in and do the job. We must find the understanding, the ability, and the courage to tell the people that at bottom industry is only their servant and can only do their bidding.

POSTWAR COSTS

The public is beginning to realize that the same automobiles, refrigerators, and houses, that were being produced in 1940 and 1941, will cost 20 to 30 per cent more when we get around to peacetime business again. This is the inevitable result of higher labor rates; these have increased 48 per cent in durable-goods manufacturing since January, 1941. Weekly "take-out" has increased 67 per cent during the same period, but this difference will largely disappear with the disappearance of overtime and other wartime bonuses. We will not see any reduction in hourly rates when the war ends; on the contrary there will be pressure for still higher rates as overtime payments vanish and weekly earnings decline.

You may have heard the opinion that a "day of reckoning" is coming for labor when the war ends; that there will be serious unemployment, and a major decline in wages and market prices.

I do not believe this will happen; if it does, it will be a day of reckoning and calamity for management, for labor, and for all of us.

American industry, at its best, has never opposed high wages nor has it been afraid of them, providing only that wages paid represent a fair distribution among the owners, the needs of the business, labor, and the public.

We have been trying to figure what the profit position of some of our major lines will be after the war, based upon current labor rates, no overtime, and current price ceilings which are substantially 1939 or 1940 prices.

One of our lines of standard machinery made a profit of $2,000,000 (before Federal taxes) in 1937, on $19,000,000 billings. On the same billings and current prices and labor rates today there would be no profit before taxes; the entire $2,000,000 would be absorbed in higher wages and salaries. Labor has acquired the shares of all the others, including the government's share in taxes.

We have made a study of longer-term changes extending for 30 years back of the costs of a 5-hp industrial motor. In 1914, the earned labor rate in this factory was 26.5 cents per hr for a 54-hr week; today it is $1.23 per hr for a 40-hr week. On straight time, including incentive pay, the weekly earnings were $13.50 in 1914 and are $49.20 in 1944.

The manufacturing cost of this motor has fluctuated during these 30 years; during and immediately following the first world war the factory cost and selling price nearly doubled the 1914 figures. But the factory cost today at $1.23 labor rate is substantially the same as it was in 1914 with a 26.5-cent labor rate. This accomplishment is mainly the result of improvement in engineering design, in materials, and in equipment and methods. It is again clear that most, if not all, of the benefits of this more skillful management have gone into the pay envelope of the workers.

No one wishes to go back to the low wages and long hours of 1914; but we may well be concerned as to our ability to continue this upward trend in wages without more effective co-operation from official labor in the economical use of labor.

In the organization and early operation of new plants, we have had an unusual opportunity to watch the effect of incentive wage-payment plans in direct comparison with day work without incentive pay.

In the new Naval Ordnance Plants, operations were started on a day-work wage basis. As soon as the workmen in any department became sufficiently skilled, a "standard-time" wage-incentive plan was started. Incidentally, this mass operation required many approximate estimates and unorthodox methods. No time studies were available for ordnance operations, because such studies and incentive plans are illegal in government arsenals. We had to start from scratch. We had an agreement with the unions (both CIO and AFL) that we would start off with liberal temporary time values, and, within six months, as the workmen became more familiar with their jobs, we would establish lower permanent values.

Based on these experiences in four different plants, ranging from 2500 to 9000 employees, I am certain that any fairly administered incentive plan, no matter how crudely set up, is better than a day-work wage plan. In department after department, improvement in production and in individual earnings was obvious as soon as the first preliminary time values were established. There is so much to be gained from the opportunity to earn more that an incentive plan can be in-

stalled without any elaborate time studies or systems and with admittedly liberal time values, and still show a profit for both company and employees.

We have had a very striking experience in the opposite direction in a plant where there was no knowledge of a reasonable day's work nor any set time values. In this plant the union contract prohibits any wage-incentive plan. In one building with about 1000 workmen, the introduction of estimated time values for scheduling purposes only, showed in the first month that the actual time taken was equal to $2\frac{1}{2}$ times the scheduled standard time. Thus the output was only one third of what would have been expected under standard-time values and wage incentives. But the low actual output was due even more to management and supervision than to workmen.

Actual experience in the same plant has shown the fundamental differences and requirements that separate true mass production from job-shop techniques. "Job shop" may not be the right word, but I include in it most of our naval-ordnance and electrical-machinery manufacturing operations.

A mass-production factory may be compared with a regiment marching in close order. Any fall-down, any individual who even gets out of step, is immediately conspicuous. Any holdup in the procession is obvious.

Job-shop operations may be compared with many separate squads, each with a different objective. No one squad is related to any other; each requires individual supervision and direction. Each one, if left to itself, may set its own pace.

Mass production requires complete preparation before operations begin, but, when production and assembly lines are functioning smoothly, relatively little supervision and paper work are required for successful continuous operation.

Job-shop operations reverse this emphasis; preparation is much less complete, but supervision in operation must be continuous, and the production system is complicated by the large number of unrelated jobs in the same area.

Most of the theoretical discussions of costs and prices by economists and others outside of industry assume a mass-production background. But the largest part of heavy machinery is produced under job-shop conditions. Opportunities for cost reduction under job-shop conditions are largely limited to original design of the product and good over-all management. There is volume to work on and time for progressive year-by-year cost reduction only with mass-produced goods; but the answer is not to undertake mass-production techniques prematurely; millions have been lost in such attempts. The real answer is to push more individual products into the mass-production class. This, however, is no overnight job. It involves creative sales and promotional price policies; engineering ingenuity to limit sizes and designs, to standardize materials and component parts; and factory-organization policy to segregate standard parts and products from specials.

There is another side of our war-production experience that has a bearing on our postwar cost position.

Taking Westinghouse operations, as a whole, the ratio of manufacturing costs to billing value is just about the same if we compare 1939 operations with 1943 operations; and with 1943 operations before renegotiation and voluntary price reductions.

This means that all of the cost reductions we would naturally expect from larger volume and less variety of products have been canceled out by the added costs of training inexperienced workers and supervisors, higher wages and salaries, and wartime bonuses.

Another indication of this same situation is the ratio of factory expenses to productive labor—the expense rate per hour; this ratio has considerably increased since early 1941 when, with greatly increased production, it should have decreased. This rate would have decreased, except for the same added costs previously mentioned, brought about by a rapidly expanding working force, higher labor rates, and overtime bonuses.

The remarkable production record of American industry during the past three years has been achieved at a price. On closer study the "miracle of war production" is discovered to have a natural explanation in resourceful management, liberally provided facilities, plenty of hard work, and the expenditure of money without stint.

This poses a postwar problem for all manufacturers. This is the problem of restoring low operating costs to its No. 1 position in our thinking; restoring low costs and expense control to the important positions they occupied before the necessities of war pushed them into the background. Wartime schedules, high production volumes, and excess-profit taxes may become insidious enemies of economical management if they are not watched. This is one of the intangible reconversion problems that every war plant faces and which may easily be overlooked.

POSTWAR PRICES

In the transition from war production to more normal peacetime conditions, manufacturers will find themselves with high wage and salary rates, a management and supervisory organization that is production- and quality-minded, but still callous with the scars of wartime extravagance and with selling prices frozen at prewar levels.

As I have indicated before, manufacturers will need all the help they can get from better management, better engineering, better equipment and methods, and, above all these, help from a wise labor-union policy, if industry is going to survive in a healthy condition and provide jobs during this difficult transition time. Industry will also need freedom from rigid price control, because many products will need higher prices at least temporarily if companies are to weather the storms of this early postwar period. I repeat there are still many opportunities for cost reduction, but these will require time to develop and to appear in operating incomes.

It will require all the "tools" we have to meet the challenge of high wages and competitive prices. I say "competitive prices" advisedly because, while I believe in the long-term advantages of low selling prices, particularly in consumer goods, industry cannot grow strong in the straitjacket of rigid government price control. Industrial managements are in the middle between the market pressure for lower selling prices and labor pressure for higher wage rates. So far, stockholders, fortunately for management, have developed no equally effective pressure for higher dividends.

The Westinghouse Economic Research Committee, that I have already referred to, has made a study of prospects concerning postwar prices, and it may be interesting to consider their conclusions. The postwar price level is one of the major assumptions upon which any rational forecasting of business volume should be based because historically, and in human nature, there is a close relation between the behavior of prices and the volume of business. When general prices are increasing faster than costs, business is generally good, and, when prices are declining faster than costs decline, then business is very apt to be bad.

CONCLUSIONS OF ECONOMIC RESEARCH COMMITTEE

The Economic Research Committee sums up as follows:

"The argument (as to prices) is between two contradictory concepts of postwar business volume. If, as happened after the last war, there is a very active demand for goods and general confidence in the prospect for future income, the great volume of money and credit placed in the hands of individuals and enterprises by wartime government borrowing is likely again to circulate freely and generate pressure for higher prices. If, on the other hand, there is general reluctance to spend or

(*Continued on page 535*)

ORDNANCE SUPPLY DEPOT FOR AUTOMOTIVE PARTS, WHERE OLD AND BROKEN PARTS ARE EXCHANGED FOR NEW ONES

ARMY ORDNANCE *in* *the* SOUTHWEST PACIFIC

By COL. W. A. WEAVER, U.S.A.

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AT this time my remarks must be wholly confined to the situations and conditions existing from the early spring of 1942, until last fall. During that period, we operated as part of the United States Army Forces in the Far East. In order for one to appreciate fully that part of the combined teamwork which Army Ordnance plays in an advanced base or zone within a theater of operations, it is necessary to consider the peculiarities of the country in which that theater is operating and of the many local conditions which affect these operations.

AUSTRALIA, THE TIMELESS LAND

Australia may well be called the "Timeless Land," and New Guinea with its surrounding islands, the "Beautiful but Treacherous Land of No Man." American soldiers had never before set foot on these lands. A new and very different peoples had to be dealt with. Terrain and climatic conditions never before encountered by the Americans of today presented a formidable barrier to all operations.

We finally arrived at our destination in the spring of 1942, a destination, incidentally, which had to be changed three times while we were en route, because the Japs were driving down from the Philippines, only after having traveled 12,000 miles; 6000 of these miles through seas that were infested with Jap aircraft carriers as well as surface and underwater craft. These Japs were strong, tough, seasoned by jungle fighting all the way down through Borneo . . . Malaya . . . Java . . . the Caroline Islands . . . into New Guinea and the Solomons to the east.

The objective of the Japs was to get control of New Guinea, New Caledonia, the Solomons, and Australia itself, which would in the process cut off all sea lines of supply to Australia. General MacArthur had only just arrived to set up his new headquarters in Australia.

Combined forces were hurriedly setting up and attempting to hold positions in a great arc extending from the Indian Ocean all along the north coast of Australia, then east to New Guinea, then curving southeast to New Caledonia, with the flank anchored in New Zealand.

Most forces were "Aussies," with a handful of New Zealanders, Dutch Colonials, and Americans. To give an idea of the size of the theater of operations: Australia is the same size as the United States, with New Guinea lying across the north and northeast coast, and the Coral Sea lying between. Of the 6,000,000 people in Australia, 90 per cent live in a few cities on the extreme southern and southeastern coastal rim. The rest of the country is wasteland and a huge desert. Geologically, this is the oldest land in the world . . . and time has not improved it any.

Port Moresby . . . 300 miles across the Coral Sea, and the Great Barrier Reef was a typical little Southsea island town of a hundred or more whites and a native section built out over the water on poles. From Moresby to Buna Mission on the north shore is only 120 air-miles, and Lae to Milne Bay only

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ELECTRICAL AND CARBURETOR OVERHAULING SECTION AT WORK

500 air-miles. . . . sounds simple! These air distances convey no impression of the difficulties actually encountered going overland. The youngest mountain range in the world runs the entire length of New Guinea like a huge jagged backbone . . . 14,000 foot ridges, and deep narrow valleys with the passes over the hump from 8000 to 12,000 feet high. On the south side there is a wide belt of dense dripping jungle and on the north, high parklands almost to the north coastal jungle strip.

It is always hot in Cape York Peninsula and New Guinea. Sometimes, in the middle of the night, the humidity will drop and the temperature will go down to 90 or so . . . that makes everyone feel refreshed temporarily . . . but . . . with sunup—a blazing ball at 6 a.m.—everything goes back to normal, and the temperature rises rapidly to 120 to 140 degrees. Rainfall often reaches 100 inches in 30 days and there was one instance of a rainfall of 63 inches in 48 hours.

A NIGHT IN NEW GUINEA

A typical twenty-four hour period goes on the average about like this: It is midnight . . . rain has been coming down in sheets for the past six hours . . . the jungle stench has about subsided . . . your blood stops pounding, and your splitting headache has about stopped. The rain lessens to a fine drizzle and the patter of the rain on the leaves ceases. Under your mosquito bar you thrash around and tuck it in for the tenth time and hunt down the last few dozen ants that are on your legs and stomach and squash them. The moon comes out bright as day and the stars are big and blue-white. Insects hum and the tree frogs and toads boom out in double bass. A single night fighter, finishing his run, whines overhead and comes in to land on the strip near by. You hear the far-off THUMP-THUMP-BOOM-THUMP of the bush telegraph. Just as you are dozing off, a jeep and a heavily loaded ammunition truck come snarling along through the mud on the trail, followed by a small group of natives jabbering. Once again you try to sleep but you are interrupted by some joker in a pea-shooter that skims down just over the beach, and immediately a dozen voices loudly complain and make uncomplimentary remarks about that pilot's ancestors. It is now about 2 a.m. and you feel it should be almost dawn . . . you are suddenly and instantly wide awake as the "HOOTER" (which is the local air-raid warning) starts to whine. You automatically pick up your shoes, shake them out . . . grab your torch . . . and cigarettes . . . put on your raincoat (because you have been sleeping raw) and walk to your slit trench, being sure to take your helmet along. You then inspect the bottom of the slit trench with your light for snakes, lizards, etc. If any animal is in it, someone shoots it on the spot.

Night fighters are now warming up and taking off from the strip a few hundred yards away, and they circle and climb to gain altitude. You, plus one or two others, sit down on the edge of the trench with your feet hanging in and light up a cigarette to await developments. All this has taken less than three minutes. At one time we had 18 or 20 minutes warning. . . . now it is much less. The HOOTER is now sounding the attack by a series of short whines. Bets are being placed as to what the Nips will hit tonight.

As they come in over the area of the target, which is us, all our searchlights go on at once . . . and there they are . . . 27 nice little silver-white float-plane bombers in perfect formation and looking perfectly harmless. Some wag sitting near by, who it seems brought along his binoculars, is announcing by box-score technique, the approach run, and what type ships they are. You can now hear your own fighters, but cannot see them and the first you know where they are is when little pin point squirts of tracer bullets string out toward the Nips. Our ack-ack is silent because our ships are up; that is, all except one Aussie 3-inch battery who either didn't get the right dope or who decided to wage war on their own hook.

The bombers split up now into three groups of nine planes each and swing around for their bombing run. The lights are still on them and back they come. If you had made any bets on the results, your interest would now be directed to hoping that they did not hit any of the installations for which you were responsible, such as your maintenance area or "ammo" dump or your unit mess. Suddenly you hear the WHOMP . . . WHOMP . . . WHOMP . . . of some medium-size bombs dropping several hundred yards off toward the dispersal area of the strip. You then feel better because you do not stand to have a hit in your own installations . . . that is, unless they drop some short or over.

No escort fighters came with the Nips tonight so no dog-fights are in progress. All of a sudden you hear the "swishy flutter" and everyone ducks in the bottom of the hole and a light 60-KG bomb lands about a hundred feet away. You

SMALL ARMS REPAIR AND MAINTENANCE SECTION AT WORK

AMMUNITION SUPPLY POINT

SORTING AND STORING SPRING LEAVES FOR ISSUE

STACKING AMMUNITION IN A NEW GUINEA DUMP

AMMUNITION BEING LOADED ON A TRUCK FOR DELIVERY

CARRYING SAND BAGS FOR AMMUNITION BARRICADES

REPACKAGING AMMUNITION DAMAGED BY ENEMY ACTION

have the sensation of someone hitting you over the head with a sledge hammer, and fragments whine off into the bush. No bad effects on anyone, and then all is quiet except for one of our own fighters with engine trouble as he comes in to land. The others have taken off after the bombers who, up to that moment, were all healthy as far as we could see and were on their way back to Rabaul.

Suddenly you realize that the mosquitoes (or mossies) have been having a free lunch under your raincoat. You cuss and gripe about it and walk back to your tent. The last bomb threw fragments through your tent, and the tags of torn canvas are hanging down inside, but luckily your mosquito bar is still intact, so you climb back in bed and about that time the HOOTER sounds the "all clear!"

DAY BREAKS IN THE JUNGLE

It is now about 3 a.m. and you unconsciously start to count the fighters coming back to land. You are not sure of your count . . . but you will hear the dope in the morning at chow-time. Finally, you drift off to half-sleep as by 4 a.m. the air of the jungle again begins to stink and you begin to sweat hard. You get up and eat chow at daylight, and the sun booms up and your blood starts to pound once more and you have a dull ache at the base of your skull.

The heavy stench of rotting vegetation, combined with the sickly sweet smell of flowers clogs up your nose. You wash down your daily slug of quinine, from 30 to 40 grains, with a little tea. Your head now gets as big as a barrel and the bells start ringing inside. The day gets hotter as you go about your work, and your head feels worse, but there is nothing to do about it, so you just cuss and let it go at that. Most of the day you are at hard manual labor, officers and men alike. It may rain hard for an hour or so during the day and then you steam and smell like a goat. A tin of hot tea makes you feel better and you are hungry for some good food. Unfortunately, the Nips sank the last refrigerator ship, and there it is lying on its side out on the reef, all burned out and still smoking. You eat some boiled pumpkin . . . rice . . . tea . . . and canned Aussie cheese or a small piece of oily mutton. That was when we were on Aussie rations.

Finally, work stops for the day at sundown . . . it is never really finished, and so ends the twenty-four hours only to be repeated . . . again and again.

WORK OF ARMY ORDNANCE

Army Ordnance work includes the following responsibilities in the forward areas:

Ammunition. The receipt and unloading of all types and calibers, including bombs, from ships. The hacking out of storage dumps to hold anywhere from 5000 to 50,000 tons. The renovation of this ammunition and the recrating and packing. The issue to troops under your area command.

Weapons. Issue, inspection, repair . . . both in position and in our maintenance shops put up in the field. Collection and salvage. All echelons of repair down to and including arsenal work.

Fire Control. Receiving, checking, testing prior to issue to batteries, and the complete servicing and overhaul.

General Supply. Receiving, storage, and issue of thousands of spare parts and major items that run into the thousands.

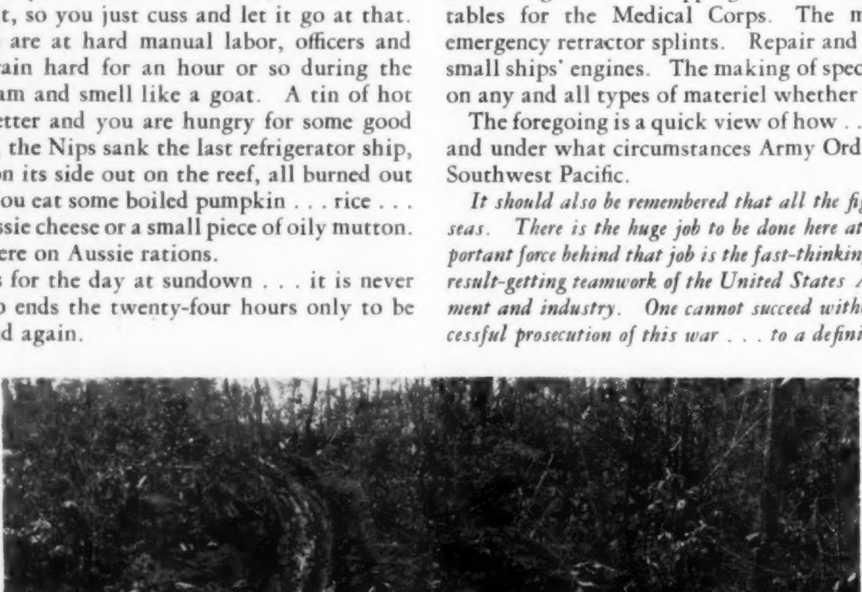
Automotive. Receipt, both as complete vehicles and also as knockdown vehicles ready for assembly. Complete overhaul of all types in the field from the jeeps and the small water carriers to the huge wreckers. Rebuilding of engines down to and including reboring, pouring of new bearings . . . chassis and body work including final painting and placing back on the ready line.

Ship-Arming Service. To include the checking and repair or replacement of all ships' weapons and their fire-control instruments. Checking of the ammunition in the ships' magazines for serviceability, replacing of and training of the gun crews and the supplying of ammunition.

Odd Jobs. All sorts of extracurricular activities, such as converting the zinc shipping cases of directors into operating tables for the Medical Corps. The manufacture of many emergency retractor splints. Repair and maintenance of many small ships' engines. The making of special modification work on any and all types of materiel whether Ordnance or not.

The foregoing is a quick view of how . . . when . . . where . . . and under what circumstances Army Ordnance operated in the Southwest Pacific.

It should also be remembered that all the fighting is not done overseas. There is the huge job to be done here at home and the most important force behind that job is the fast-thinking . . . hard-hitting . . . result-getting teamwork of the United States Army Ordnance Department and industry. One cannot succeed without the other in the successful prosecution of this war . . . to a definite victory.



LOADED AMMUNITION TRUCK HAVING HARD GOING UP STEEP GRADE
(Mud condition extreme due to 64 in. of rain in 48 hours.)

THE SIKORSKY XR-5 HELICOPTER ON THE GROUND

DIRECT-LIFT AIRCRAFT

By IGOR I. SIKORSKY

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THE idea of flying was always associated in man's imagination with the correct solution of two problems, namely, (1) traveling through the air at high speed, and (2) the possibility of departing from and arriving at any spot on the surface of the earth, be it mountains, valleys, swampland, jungle, or any such place, even though surrounded by obstacles. Problem (1), transportation, was solved admirably by the airplane. However, the real solution of problem (2) was for a long time postponed, and it even became an accepted opinion that aircraft would always be operated only from large well-surfaced airports situated some distance outside of cities, or from large bodies of water. The objective of the direct-lift type of aircraft is to eliminate this obstacle and to permit flying from any backyard, from the roof of a building, from small clearings, and in fact from any spot where there is room enough for the structure of the machine, with a safety margin of a few feet to spare.

The helicopter is a direct-lift aircraft and is capable of such performance. The fundamental principle of the machine, in which all lift is derived from one or more lifting rotors to which the power is applied from the engine, is very simple. The conversion of that principle into practice, however, necessitated the correct solution of a number of problems so difficult that, for a while, doubts were expressed that a practical helicopter would ever become a reality. Nevertheless, the extensive research and engineering development that has been carried out by our organization, followed by that of others, during the last four years has eliminated all such doubts. Out of this work has evolved an aircraft capable of taking off directly with no run whatsoever, hovering in the air over one spot, flying forward, backward, or sideways, ta any desirable speed between motionless hovering and the maximum speed of the craft. It is possible for this craft in flight to approach a man and hover in the air while a suitcase is placed on board, or while a mechanic unscrews a nut and removes a wheel, fixing a tire and later replacing it on the craft still hovering near by. Quite frequently, this craft has taken off and landed on the roof of a small shed, and in many other restricted areas.

THE SIKORSKY XR-6 HELICOPTER IN FLIGHT

(This newest version of the Sikorsky helicopter, a two-place military model, is to be built for the Materiel Command of the U. S. Army Air Forces.)

Some of the most interesting characteristics of a helicopter are in connection with the use of inflated rubber bags as a landing device. With this gear, it can be safely operated from ground, from water, from a swamp, from deep snow and even from thin ice because if that breaks, the machine will still remain afloat. It is scarcely necessary to emphasize the importance of such a machine for an almost endless number of services of a military as well as of a private nature.

Speed in flight will be relatively slow for a long time to come, and will probably not exceed 120 to 140 mph. Loads also will not be as great as with airplanes, although helicopter buses of 12 to 20-passenger capacity are not beyond reasonable expectation. However, even with such limitations, it is apparent that the innate characteristics of such a craft will qualify it to fill a great void in our present transportation needs.

SERVICE EXPERIENCES OF THE HELICOPTER

The outstanding characteristics of the helicopter have been amply demonstrated in the many recent experimental flights, cross-country trips, and actual missions that frequently have been accomplished under difficult and dramatic conditions.

Among the high lights are the 162 take-offs and landings on board a steamship in the open Atlantic, sometimes in strong winds with moderate rolling of the ship; the interesting cross-country flight of Col. H. F. Gregory and passenger from Washington to Dayton, Ohio, covering 387 miles nonstop in less

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THE SIKORSKY XR-5 HELICOPTER HOVERS A FEW FEET ABOVE THE GROUND

(This two-place passenger, tandem-seated aircraft is to be built in quantity for the Materiel Command of the U. S. Army Air Forces. It is powered with a Pratt and Whitney 450-hp Wasp, Jr., engine.)

THE SIKORSKY HELICOPTER LANDS AND TAKES OFF FROM THE DECK OF A SHIP

than 5 hr against head winds from 10 to 30 mph, crossing the Alleghenies with considerable ease. This flight established an unofficial world record for distance and duration. The delivery of blood plasma by Commander Frank Erickson of the Coast Guard for the men injured in an explosion on the U. S. destroyer *Turner* off the New Jersey Coast was the first successful practical mission ever performed by a helicopter. Commander Erickson had to fly through snow and fog which had grounded all other aircraft, land the helicopter at Battery Park on the tip end of Manhattan, pick up two boxes of precious plasma and deliver it to the hospital on Staten Island. Then there was the incident of the rescue of a boy stranded on an island in Jamaica Bay, and also the delivery of fire apparatus by helicopter to fight a fire which was giving firemen considerable trouble due to their inability in reaching it. The latest exploit of interest was a lifesaving mission accomplished in faraway Burma.

In concluding, I am convinced that ultimately the helicopter will become a very popular type of aircraft. Perhaps its public acceptance will be developed through its potential commercial uses such as mail delivery, de luxe buses, taxis, emergency air transportation, crop dusting, patroling, and other uses too numerous to mention. Eventually, it may make possible broader and more extensive use of the territory of this country by opening for residences, recreation, prospecting, and other developments, areas which now remain practically idle because of transportation difficulties.

The MATERIEL COMMAND'S *Approach to the* FLUTTER PROBLEM

By L. S. WASSERMAN

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THE aircraft flutter problem is such a highly specialized phase of aeronautical engineering that the mechanism of flutter is not qualitatively understood even by many aeronautical engineers let alone engineers in other fields. Flutter is defined as a dynamic instability of an aircraft structure for which aerodynamic forces and moments supply the energy. In a typical case, such as wing-bending versus aileron flutter, bending oscillations of the wing cause the aileron to vibrate about its hinge line, primarily as the result of aileron mass unbalance, and the air forces acting on the wing, because of the aileron motion, cause the wing to vibrate. If more energy is put into the wing by the aileron than is necessary to maintain the wing vibration at constant amplitude, the oscillations will build up with time. The motion is started by an external source of energy, such as an air gust or engine-induced vibration. An excellent discussion of the mechanism of flutter is given by Kussner (1).[1]

FLUTTER CONTROL IMPORTANT TO GOOD PERFORMANCE

Experience and theoretical considerations show that the flutter problem increases in importance as the performance of airplanes increases. This fact explains the concentrated effort expended on this problem by the aircraft industry and associated government agencies during the last five years. It should be pointed out, however, that the purpose of this work is not only the prevention of flutter but the prevention of flutter in the most efficient manner so that the resultant penalties on aircraft performance, stability, and control are kept to a minimum. Developments in flutter theory, flutter testing, and flutter model technique have gone a long way toward making the achievement of the stated purpose possible.

The action taken in regard to the flutter problem by the Materiel Command as a procuring agency has been to provide aircraft contractors with the best available information regarding flutter theory and test data, and to encourage the use of this information in the design stages. In addition, certain general requirements for flutter prevention, based upon experience with other airplanes, have been established so that contractors not able to devote sufficient engineering time to the problem are reasonably assured that their designs will be safe from flutter. Since these general requirements cover widely different types of airplanes, they are quite conservative in some cases, and for this reason the contractor is granted deviations, provided he can prove the safety of his design by rational methods of analysis and/or model tests. Thus as much freedom as possible is given to the designer provided he has the necessary facilities available to handle flutter problems. For unconventional designs, well-trained personnel working on flutter are particularly essential, since past experience is not definitely applicable. In such cases the Materiel Command requires the contractor to conduct theoretical calculations and/or flutter model tests for modes which may be critical.

[1] Numbers in parentheses refer to the Bibliography at the end of the paper.

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FLUTTER SURVEY OF NEW MODELS

For a check on the flutter-prevention measures taken during the design stage, a flutter survey is conducted on the first experimental article. This survey includes:

(*a*) Measurements of the mass distributions of the movable control surfaces.

(*b*) Structural-vibration tests.

· The former tests are simple, but are considered advisable because of the importance of the data on the flutter characteristics of the airplane. The structural-vibration tests are particularly important, since these tests provide practically all the stiffness parameters used in flutter calculations. The determination of these parameters by theoretical computation or models is not only long and tedious, but the results are likely to be somewhat in error, as aircraft structures are highly complex in nature. Moreover, the coupled deflection curves of the modes of vibration excited in these tests provide an excellent check on the mechanical parameters used in flutter analysis and also disclose points of flexibility in the structure where, if necessary, reinforcing material could be added with the greatest efficiency. Until recently, all flutter surveys of Army Air Forces aircraft were carried out by Materiel Command personnel and equipment. However, the present trend is toward having the tests conducted by the contractor and witnessed by a Materiel Command representative. This procedure, of course, can be followed only in those cases where the contractor has accumulated adequate flutter-test experience, personnel, and equipment.

KNOWLEDGE OF VIBRATION THEORY ESSENTIAL

The analyses of ground-vibration test data are far from simple and straightforward, since the airplane is an elastic body with a large number of important degrees of freedom, that is, many co-ordinates are necessary to represent the vibratory motions rigorously. Motions of any part of the airplane are thus reflected throughout the whole structure, and every resonant frequency corresponds to a mode of the complete airplane rather than the mode of the particular structural component to which the vibrator is attached. The mode is usually defined for convenience as a resonance of the component undergoing the most pronounced elastic deformation. For example, the mode called "symmetrical wing bending" involves large symmetrical wing-bending vibrations and usually comparatively small motion of the fuselage and tail surfaces. Pronounced motion will sometimes occur, however, in the fuselage and tail surfaces, particularly in twin-tail airplanes, and in these cases the motion of the whole airplane must be determined simultaneously. Strong interaction also occurs between torsional and bending responses so that, for example, pure wing torsion is almost never observed. The results are further complicated by the fact that it is difficult to determine the difference between a natural mode of the structure and a response in which one part acts as a dynamic vibration absorber for another part. In one actual case a Pitot tube attached to the leading edge of a fairly flexible wing resonated in bending, reduced the wing-bending response, and caused a fairly pure torsional-response peak which, however, was not a natural structural torsional mode of the wing.

The test engineer must therefore have a sound knowledge of

vibration theory as well as suitable equipment for careful measurements of the response of the structure. Much developmental work has been carried on along the equipment line, with the result that suitable electronic devices are now available for accurate phase, amplitude, and frequency measurements (2, 4). For exciter equipment, rotating-weight vibrators directly attached and crank connecting-rod mechanisms elastically coupled to the structure have been used with electric drives capable of holding constant speed. At present the trend is toward electromagnetic shakers (3). This last type has the following advantages:

(*a*) The vibratory impulses from individual shakers located at various parts of the structure can be easily phased,

(*b*) The magnitude of the applied oscillatory force or moment can be easily adjusted.

The disadvantages of this equipment are large size and weight and the difficulty of attaching the vibrators to the structure. Thus it does not appear suitable for applications requiring simplicity in the experimental setup and portability.

MODERN FLUTTER THEORY

After the ground vibration-test data have been obtained, the flutter possibilities of the design are determined by approximate theoretical methods. The complicated dynamic characteristics of aircraft structures, combined with the difficulty of determining experimentally or theoretically the values of the oscillatory aerodynamic forces and moments, make a rigorous solution of the differential equations of motion impractical. Even if the aerodynamic effects were known, the solution of the differential equations would require the solution of a large number of simultaneous equations linear in the variables representing the motion of each degree of freedom and having in each equation an unknown parameter inversely proportional to the square of the flutter frequency. While recent developments by the C.A.A. and Bureau of Census have shown that these equations can be solved by automatic machines (4), the work involved in setting up the equations appears too long to be practical for routine cases.

An engineering approach to the problem had to be made which would give a reasonable representation of the mechanical system by means of a small number of independent variables. An examination of the problem on the basis of energy consideration showed that, if the elastic curves in the flutter mode were known, a few equations could be used to determine whether or not the aerodynamic energy input exceeded that absorbed by the structure, that is, whether or not flutter would occur. Using the Rayleigh method for computing frequencies as a guide, it was reasoned that small errors in the deflection curve would not have a large effect on energy computations so that, if the deflection curves could be approximated, the results of an energy calculation, based upon these curves, should give a reasonably accurate value for the critical flutter speed.

STUDIES OF VIBRATION MODES UNDERTAKEN

An investigation of the important vibration modes of aircraft structures excited in ground tests was made with the idea that, if the deflection curves in these modes could be represented as the sum of a few simple curves, then these curves could be used in the flutter analysis. For, if the large and often irregularly distributed inertia coupling forces and moments had little effect upon the deflection curves assumed to represent the motions of the structure, then the effects of the more uniformly distributed aerodynamic forces and moments would also be small.

The results of the investigation disclosed that the deformations of the vibration modes important from the standpoint of flutter could be reasonably represented by as few as three elastic curves in the majority of cases. These curves were found to be nearly the same as those representing the uncoupled vibration modes of the structure in bending, torsion, and control surface rotation. If these curves were used in the energy calculation and another degree of freedom, involving the motion of the airplane as a rigid body, were added to satisfy the equations of equilibrium of the airplane in regard to the inertia forces, the vibratory motions of the important coupled modes of the part of the structure being analyzed could be computed. The problem was thus reduced from one having a large number of degrees of freedom and almost impractical of solution with existing methods to one having as few as three or four degrees of freedom and suitable for routine analysis. It must be kept in mind, however, that the deflections obtained by the foregoing procedure do not satisfy the actual differential equations of motion.

The contributions of the aerodynamic effects to the energy of the system were evaluated on the basis of linear two-dimensional potential theory (5, 6), since refinements in the theory to cover the actual shapes of the oscillating wing were not practical, although some approximate corrections are now available. The aerodynamic theory of an oscillating airfoil is complicated by the velocity of propagation of oscillatory disturbances created in the air stream by the vibratory motions of the airfoil, so that the forces and moments are functions of the so-called reduced velocity, that is, the ratio of the number of chord lengths per second traversed by the airfoil along its flight path to the flutter frequency. The effects of the disturbances mentioned and the fact that the vibratory displacement, velocity, and acceleration all affect the airflow cause the resulting aerodynamic force or moment to have a time-phase angle with respect to the vibratory displacement, so that a complex or vector notation is used. These vectors have been tabulated numerically for routine computations in terms of the reduced velocity and certain parameters whose values depend upon the positions of the leading edges of movable control surfaces and tabs.

To the flutter engineer the numerical values of these aerodynamic vectors are subject to question, since, in addition to all the errors inherent in linearized potential aerodynamic theory, no theoretically exact corrections are available to include:

(*a*) The effects of disturbances set up by variations in the spanwise loading.

(*b*) The effects of compressibility.

SETTING UP EQUATIONS FOR FLUTTER ANALYSIS

With the approximations for the mechanical and aerodynamic parameters, the procedure required for flutter analysis is straightforward. Equations are written stating that the rate of change of total energy (aerodynamical plus mechanical) in each degree of freedom is zero; that is, any change in the effective kinetic plus potential energy (aerodynamical plus mechanical) equals the energy removed (or put in) by the nonconservative forces and moments, including the structural damping in each degree of freedom having elastic energy. The solution of the determinant of these equations gives the frequencies of the natural modes of vibration and also shows whether each mode is stable or unstable. Once the frequency and damping for each mode are known, the simultaneous equations can be solved for the phase and amplitude ratios between the various degrees of freedom, so that the shape of the wing in its coupled modes can be calculated.

If ground-vibration test data are available, the solution is first made for zero air speed for the purpose of comparing the computed and measured coupled deflection curves and frequencies. If the agreement is not satisfactory, the uncoupled frequencies are changed or additional degrees of freedom are included. A good check between theory and experiment indicates that the mechanical system has been properly represented by the equations.

The calculations for the structure in flight are similar to those at zero air speed except that the structural damping is left as a variable in each degree of freedom and the values of the

aerodynamic coefficients are changed accordingly. The solution of the determinant yields, in addition to the frequencies, the values of the structural dampings necessary to give real values for these frequencies, indicating that for the computed dampings the oscillations will be simple harmonic, representing the border line between stability and instability. If the computed structural damping exceeds that which is actually present in the structure, the computation indicates that flutter will occur.

The air speeds applicable to the foregoing solutions are determined from the values of the flutter frequencies and the reduced velocity used to compute the aerodynamic energy. The results of these calculations are plotted in terms of the damping required for stability versus the air speed and show not only the critical flutter speed but also the violence of the onset of flutter. The method of flutter analysis described has been published by the Materiel Command (7), and also by other investigators who have used somewhat different approaches to the problem with identical results (8, 9, 10).

FLUTTER THEORY AND EXPERIMENT CHECK FAIRLY CLOSELY

The simplifying assumptions used in flutter theory make its application highly inadvisable without substantiating experimental data. For this reason, the theory has been checked against both flutter-model and flight-test data, and the results have been gratifying. In violent types of flutter, theory and experiment check quite well with respect to the *critical speed*, within about 10 per cent at least for a large number of points analyzed by the Materiel Command. For the milder forms of flutter, such as are sometimes caused by control surfaces and tabs, the theory appears to be somewhat conservative. Reliance on the theory, therefore, seems justified; and in fact, for all actual cases of *full-scale aircraft flutter* known to the Materiel Command, the theory has never been found to be other than conservative. However, caution in applying the theory is recommended since some model tests have indicated that the theory may be unconservative with respect to the *magnitude of the range of instability*. Model tests will usually indicate a wider range of unstable speeds than is indicated by the theory.

At the present time it appears that theoretical calculations are in the majority of cases the most practical means for handling routine flutter problems. Among other possible methods, flutter models appear to be difficult and quite expensive to build; and flight flutter tests are likely to be dangerous and do not give the desired information when it is most needed, namely, during the design stage. However, when the theory indicates marginal stability, and extensive and costly modifications are necessary for flutter prevention, flutter models and flight tests are essential. A considerable amount of model work has thus been carried out under Materiel Command sponsorship, and this work has yielded valuable data. Yet, at the present time, it has not been found practical to build a dynamically similar flutter model of any complete airplane in a reasonable length of time, although this goal has been closely approached. It is the opinion of the author, however, that the effort expended in model work is well worth while, since such models could be used for structural, stability, and perhaps high-speed performance work in addition to flutter testing, and thus offer many advantages over the rigid models now used in wind-tunnel tests.

DIFFICULTY OF FULL-SCALE FLIGHT TESTING

In any case, the final proof lies in the behavior of the actual airplane, so that full-scale flight flutter testing cannot be overlooked. Experience along this line indicates that this type of testing is made difficult by nonlinear parameters in the structure, such as friction, decrease in structural stiffness with deflection, play in movable control surfaces and tabs, preloaded springs, and control-cable stiffnesses. In general, the nonlinearities cause the degree of instability to increase with the amplitude of vibration. Thus even a type of flutter which the theory shows to increase gradually in severity with speed may turn out to be explosive. Furthermore, if the theory indicates the likelihood of an explosive type of flutter, it will be even more dangerous to check this in flight. Experience at the Materiel Command with flight flutter testing has indicated an unpopularity of this type of testing with many pilots and test engineers.

The necessity of flight-test data for checking flutter theory and for determining actually the safety of an airplane shown to be marginal by the theory is responsible for the importance given to this work by the Materiel Command. The goal is to obtain a foolproof technique which not only can be used for this purpose but also will show possibilities of reducing the mass balance and structural stiffnesses required according to the theory for flutter prevention.

TESTING TECHNIQUE

Some tests using radio control and telemetering of the flutter data have been completed, and further development along this line is being carried out, but the most practical procedures at the present time require flying personnel to be in the airplane being tested. The technique for these tests involves the excitation of the structure to determine either the peak response or the decay curve of free vibration as functions of the air speed. For excitation, a mechanical type of vibrator driven by an electric motor was used for high frequencies, whereas manual excitation by means of the control stick or rudder pedals was used for low frequencies. Measurements of the structural response were made by means of electrical vibration equipment, including pickups, amplifiers, and a multichannel recording oscillograph. Typical records obtained in several of the tests conducted to date are shown in Fig. 1. The success of these tests is due to a careful theoretical analysis of the flutter mode before the tests were carried out. Such a procedure is considered highly advisable.

THEORY POINTS WAY TO FLUTTER PREVENTION

If a given design is found to be critical from the standpoint of flutter from flight tests, model tests, or calculations, suitable methods of flutter prevention must be found. Here again, the theory is used, since it represents the most practical approach for obtaining a solution to the problem in a reasonable length of time. Model tests and/or flight tests may be required for checking the effectiveness of flutter-prevention measures dictated by the theory, but despite the many simplifying approximations used, designers and engineers must rely largely on the theory. (A few prayers also come in handy.)

THE MAINTENANCE PROBLEM

In connection with methods used for flutter prevention, careful attention must be paid to the effects of service conditions and maintenance difficulties. Experience has shown that flutter will sometimes occur after an airplane has been in service for some time, despite the fact that the airplane may have been dived to its limit speed several times without the occurrence of flutter. In these cases, it appears that either one of the factors preventing flutter in the original dives was reduced in effectiveness by service wear or that insufficient initial excitation occurred in the earlier dives to overcome the effects of the nonlinearities mentioned previously in the discussion of flight flutter testing. Dry friction in the control systems of the movable control surfaces and tabs has probably been the cause of much of the difficulty and is thus not relied upon for flutter prevention by the Materiel Command.

Under combat conditions all flutter-prevention measures, including control-surface mass balance, structural torsional rigidity, rigidity of tab- and flap-control systems, and hydraulic dampers are likely to be adversely affected. Service activities

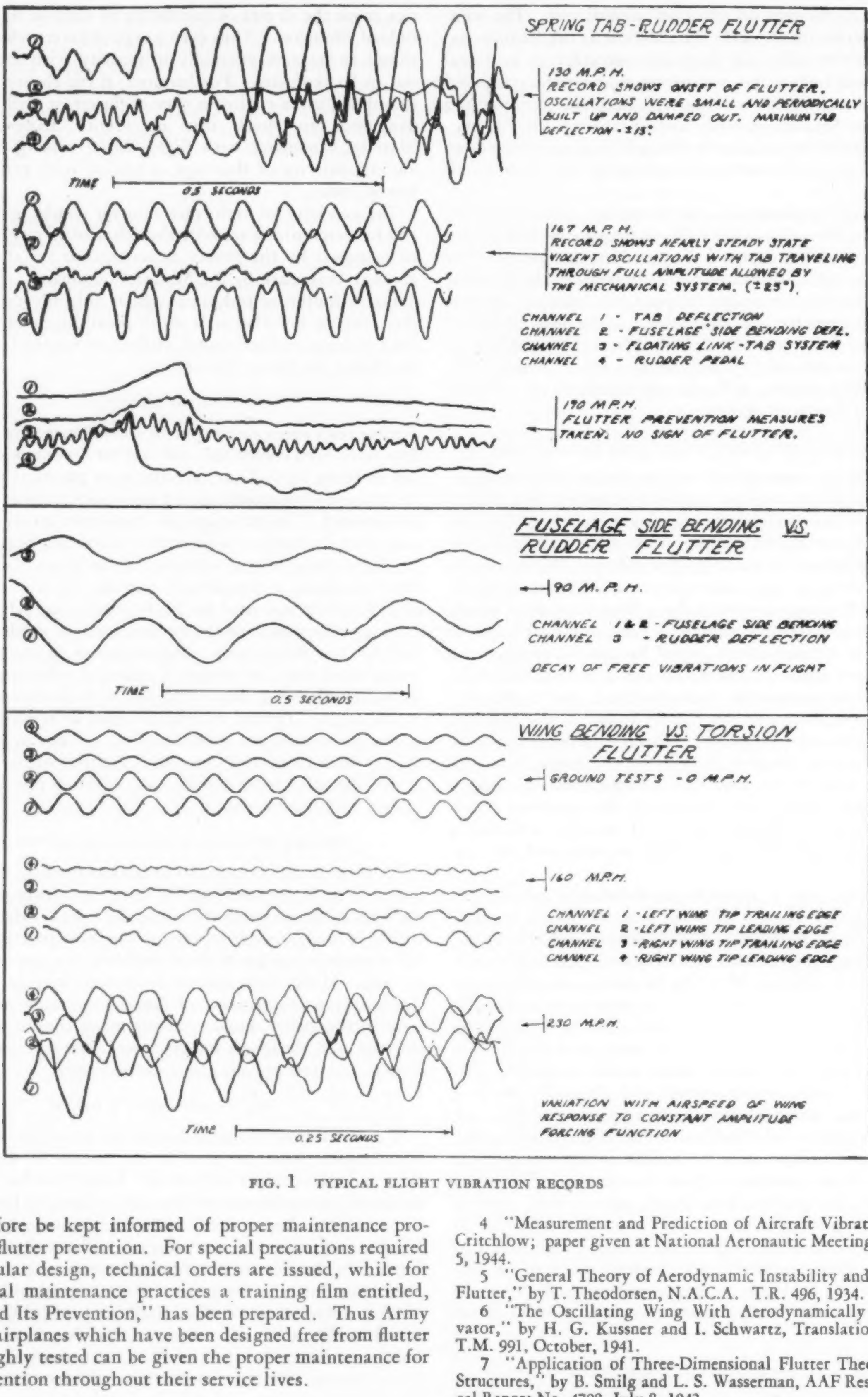

FIG. 1 TYPICAL FLIGHT VIBRATION RECORDS

must therefore be kept informed of proper maintenance procedures for flutter prevention. For special precautions required in a particular design, technical orders are issued, while for good general maintenance practices a training film entitled, "Flutter and Its Prevention," has been prepared. Thus Army Air Forces airplanes which have been designed free from flutter and thoroughly tested can be given the proper maintenance for flutter prevention throughout their service lives.

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THE ANDEROMETER

An Instrument for Production-Testing of Ball Bearings for Deviations From Circularity of Balls and Races

By LUCIAN CHANEY,[1] EDWARD BRAGG,[1] JOHN TRYTTEN,[1] AND ERNEST ABBOTT[2]

MODERN ball bearings are made to very close tolerances, even for these days of high-precision manufacture. A number of instruments are used in gaging bearing parts during manufacture, for such items as bore diameter, outside diameter, axial length, etc. It is also common practice to measure the runout of completed bearings. This paper is not concerned with such matters. It deals with a rapid production check of one type of over-all quality measurement of the completed bearings.

Ever since ball bearings have been made, the users and makers have wished to determine the quality of the completed product. It has been common practice for many years to run bearings on some sort of test stand, and to observe differences in "noise" and "vibration." Much can be learned from this method through the senses of touch and hearing. The human senses, however, are probably among the most variable and indeterminate factors with which we have to deal. This method of testing depends too much upon the interpretations of the tester and leads to many contradictions.

The "Anderometer" (Fig. 1) described in this paper, was developed as a means of measuring definitely a certain mechanical characteristic of the bearing. The bearing characteristic measured has been defined in terms of the geometric dimensions of the bearing, as explained later in the article.

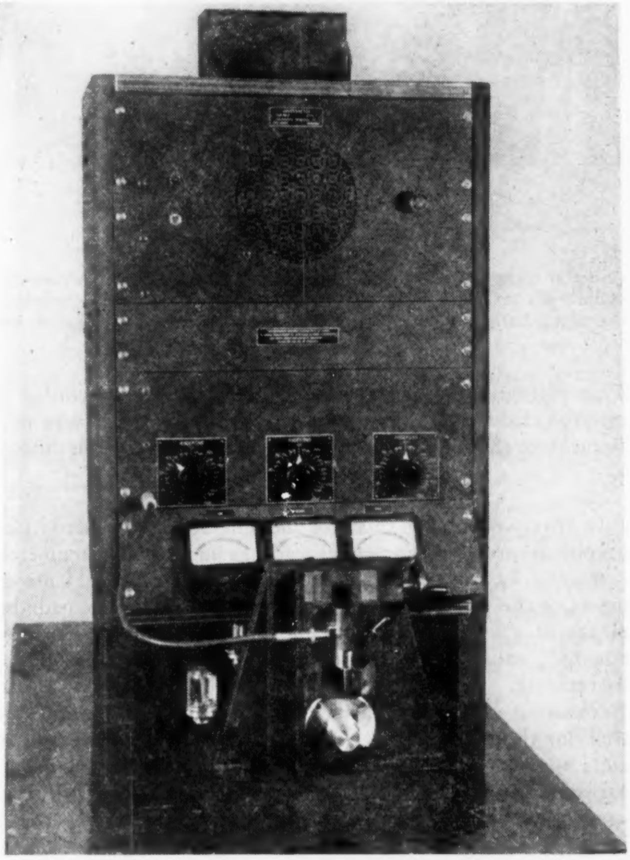

FIG. 1 THE ANDEROMETER, AN INSTRUMENT FOR PRODUCTION-CHECKING OF COMPLETED BALL BEARINGS

(In foreground is shown spindle which revolves inner race of bearing, and converter which is in contact with outer race. Behind spindle is amplifier unit, on which are mounted meters and speaker. The dials enable adjustment of amplification of instrument for testing bearings of various sizes and qualities.)

DEVIATIONS FROM CIRCULARITY OF BALLS AND RACES

Fig. 2 shows an idealized bearing with true circular parts. Fig. 3 shows the character of the deviations from circularity in a typical bearing. For illustration, the radial dimensions of the deviations have been enlarged several thousand times. The circumferential dimensions of the irregularities are natural size.

Each ball and race surface has a series of complex and irregular profiles. These complex profiles roll on each other like cams, and thus produce motions.

If we can imagine that the inner race is rotated accurately about its axis, and the outer race is restrained from rotation, then the outer race executes radial motions caused by the cam action just mentioned. The purpose of the Anderometer is to measure the quality of the bearing in terms of the height and spacings of these radial motions.

Fig. 2

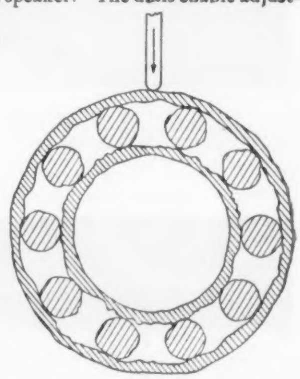

Fig. 3

FIG. 2 IDEALIZED BALL BEARING WITH TRUE CIRCULAR PARTS

FIG. 3 (RIGHT) EXAGGERATED SKETCH OF DEVIATIONS FROM CIRCULARITY IN TYPICAL BEARING

("Radial" dimensions of the irregularities have been enlarged several thousand times; no enlargement of circumferential dimensions. Because of these irregularities, bearing in rotation produces radial motions of outer race.)

METHOD OF MEASUREMENT

If a contact pin is placed against the outer race, as shown in Fig. 3, and allowed to move only in a radial direction, this pin will follow the radial component of the movement of the outer race. It is of course necessary to hold the pin against the race with sufficient force so that accelerations do not cause it to leave contact with the surface.

The movement of this pin can be measured by various means. In the present case, a small coil was mounted on the end of the pin. This coil was placed in a magnetic field, and the movement of the coil generated a voltage proportional to the velocity of the radial movement of the outer race of the bearing.

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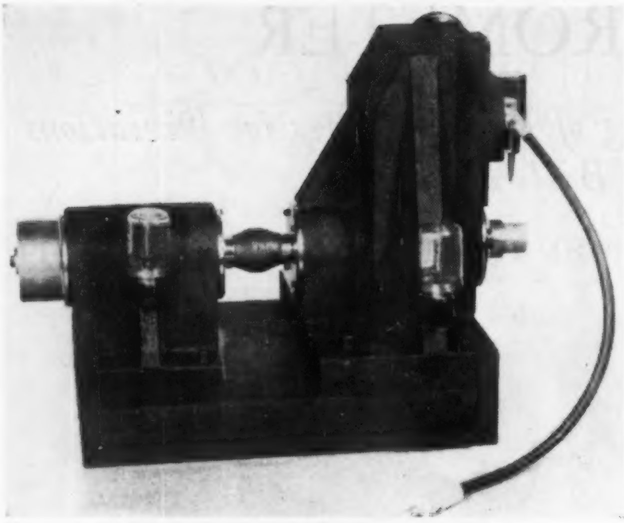


FIG. 4 THE ANDEROMETER SPINDLE

(Note at right the spindle on which bearings are slipped. Above this spindle is converter, with cable for attaching to amplifier. Spindle is driven by pulley at left, with rubber coupling between jackshaft and spindle proper.)

This voltage was then amplified, weighted, and recorded or metered electrically. Fig. 4 shows the setup which was used to measure the radial movement of bearings by this method.

TYPES OF MEASUREMENTS MADE

In this work, two types of measurement were used, i.e., graphic records, and numerical readings on an averaging meter.

Graphic Records. Graphic records of the individual movements of the pin over a selected period of time were made by means of a suitable oscillograph. Such records of "instantaneous" values are useful for detailed analysis of individual movements.

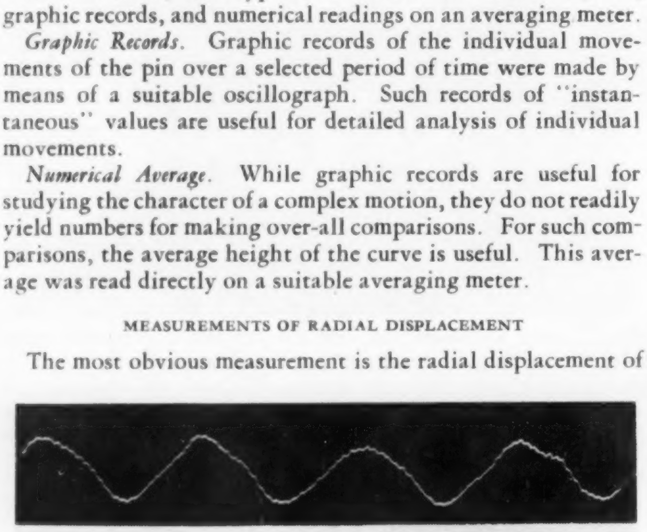
Numerical Average. While graphic records are useful for studying the character of a complex motion, they do not readily yield numbers for making over-all comparisons. For such comparisons, the average height of the curve is useful. This average was read directly on a suitable averaging meter.

MEASUREMENTS OF RADIAL DISPLACEMENT

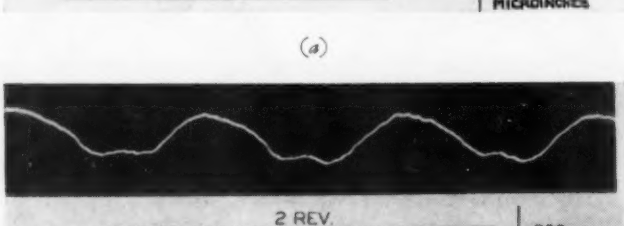
The most obvious measurement is the radial displacement of the outer race. The instrument was arranged to make measurements of this quality directly in microinches. The converter unit was calibrated by driving the pin through a measured displacement at a known frequency and measuring the output voltage. A special circuit was used in the amplifier so that the over-all measurement was made directly in terms of displacement. In making the calibration, the displacements were measured directly with a microscope. In this way, the instrument as a whole was calibrated to read directly in microinches.

Fig. 5 shows oscillograms of the radial displacement of two typical bearings. The horizontal ordinate is angular displacement of the inner race; the vertical ordinate is radial displacement of the outer race.

The largest component of motion of the outer race occurs once every revolution of the inner race. This represents the eccentricity of the bearing. Since there was evidence that higher frequency movements are important in determining bearing quality, measures were taken to reduce the effect of the rotational frequency on the measurements. This enabled the higher frequencies to be studied.



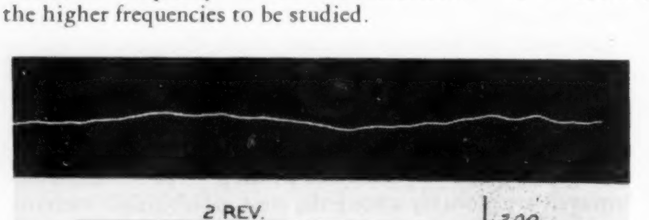
(*a*)



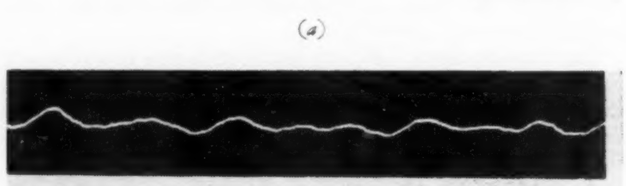
(*b*)

FIG. 5 OSCILLOGRAMS OF RADIAL DISPLACEMENT OF TWO TYPICAL BEARINGS

(Horizontal ordinate is angular displacement of inner race; vertical ordinate is radial displacement of outer race. Note that largest component of motion occurs once per revolution. This represents eccentricity of bearing.)

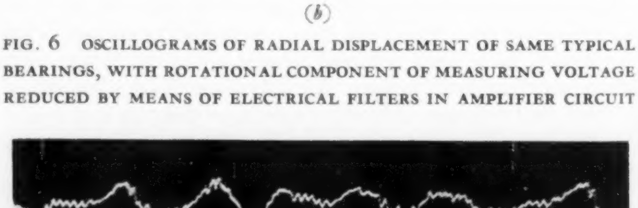


(*a*)



(*b*)

FIG. 6 OSCILLOGRAMS OF RADIAL DISPLACEMENT OF SAME TYPICAL BEARINGS, WITH ROTATIONAL COMPONENT OF MEASURING VOLTAGE REDUCED BY MEANS OF ELECTRICAL FILTERS IN AMPLIFIER CIRCUIT



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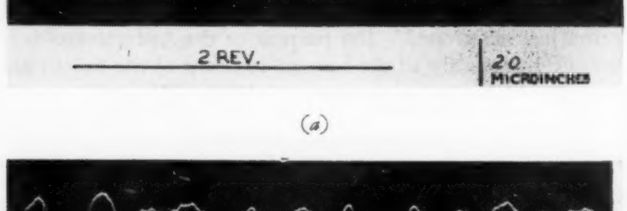


(*b*)

FIG. 7 OSCILLOGRAMS FROM SAME SETUP AS FIG. 6, WITH VERTICAL MAGNIFICATION INCREASED, ENABLING DISPLACEMENT CURVES TO BE STUDIED

(Note that average height of *a* is about $^1/_3$ that of *b*. Bearing *a* shows waves occurring 2 and 25 times per revolution, while *b* shows waves occurring about 4 and 20 times per revolution of inner race. Higher frequency components are not seen since amplitudes are of same order of size as width of line.)

The rotational component of the measuring voltage was reduced by means of electric filters. Fig. 6 shows the resulting oscillograms after this modification was made in the measuring instrument. These oscillograms show little more than a slightly wavy line. The vertical magnification was then increased; the results are shown in Fig. 7. These curves are large enough for study.

Comparing Fig. 7(*a*) with 7(*b*) reveals a decided difference in the character of the two waves. The average height of (*a*) is about $^1/_3$ that of (*b*). Bearing (*a*) shows a combination of waves occurring 2 times per revolution, and rather prominent shorter waves which occur about 25 times per revolution. Bearing (*b*) seems to have waves occurring about 4 and 20 times per revolution. Neither of these oscillograms shows waves which occur more often than 30 times per revolution. Higher frequency components are not seen in Fig. 7, because the amplitudes are of the same order of magnitude as the width of the line.

ANGULAR DERIVATION OF RADIAL DISPLACEMENT

In any vibrating system the "noise" or vibration produced is a function not only of the size of the displacement, but also of the frequency of the motion. For example, a system vibrating at 400 cycles per sec needs to be displaced through only one quarter of the distance required for a system vibrating at 100 cycles per sec, to radiate the same acoustic power. In this case, the velocities of both vibrating systems are equal. The relationship mentioned holds for vibrating objects which are large compared with the wave length of sound (about $2^1/_2$ ft for 400 cycles per sec). On smaller objects, the lower frequencies are not radiated as well as the higher frequencies.

The velocity is expressed in displacement per unit of time. In this case, a convenient unit of displacement is the microinch. For the unit of time, it was decided to use the time required for the inner race to turn through an angle of one radian ($57^1/_2$ deg). The reason for this choice of units is that it gives numbers of convenient size on typical present-day-production bearings. In mathematical terms, this is the angular derivative of the radial displacement, the unit selected being microinches per radian.

This type of motion is easily measured electrically by adjusting the electrical characteristics of the amplifier and recalibrating. Fig. 8 shows an oscillogram of the angular derivative of

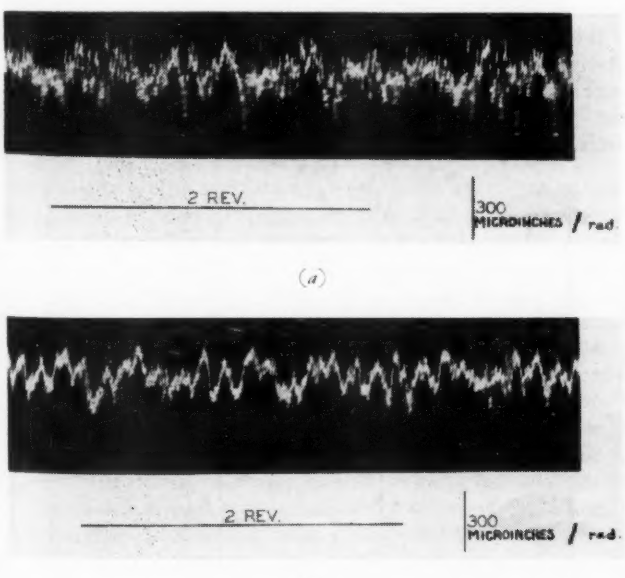


FIG. 8 OSCILLOGRAMS OF ANGULAR DERIVATIVE OF RADIAL DISPLACEMENT OF OUTER RACE AS INNER RACE ROTATES

(Unit used is microinches per radian of rotation of inner race. Note that radial motion is nonrecurrent, because of camlike action of balls and races, and fact that different parts of balls contact given parts of races on successive revolutions.)

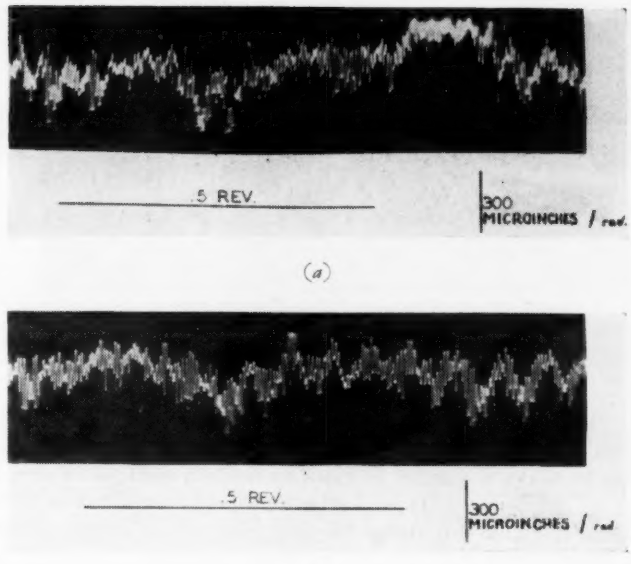


FIG. 9 OSCILLOGRAMS OF SAME TWO BEARINGS WITH HORIZONTAL SCALE MAGNIFIED, TO RELIEVE CROWDING OF CURVE

(Note that although average heights of two bearings are about the same, there is a definite difference in their characters.)

the radial displacement of the outer race as the inner race rotates. Due to the complicated camlike action of the balls and races, the radial motion of the outer race is nonrecurrent, as is evident from Fig. 8. Hence, Fourier-series method of analysis is not applicable.

These oscillograms are so crowded together that it was found convenient to magnify the horizontal scale. This is shown in Fig. 9. The average heights of the two oscillograms are approximately equal, but there is a decided difference in the character.

BAND DIVISIONS OF ANGULAR DERIVATIVE OF RADIAL DISPLACEMENT

To extend the analysis of the character of these bearing motions, it was decided to split the components into more than one band of measurement. One band included motions of the outer race occurring between 2 and 33 times per revolution of the inner race. The other band included motions of the outer race which occur between 33 and 400 times per revolution.

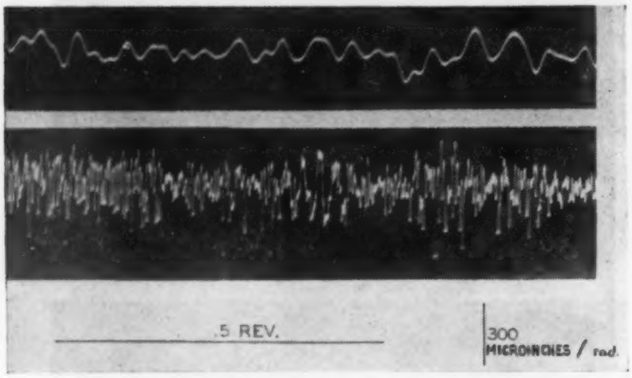
The basis of selection of bands was as follows:

The lower limit of the 2-33 band was determined by the elimination of eccentricity as just described. The higher limit was selected to include waviness and exclude roughness. It has long been known that cylindrically ground work has definite "waviness." Shopmen often call this "chatter," although measurements indicate that waviness is present when there is no visible evidence of chattering motion. These widely spaced waves generate comparatively low-pitched sound in most bearing applications.

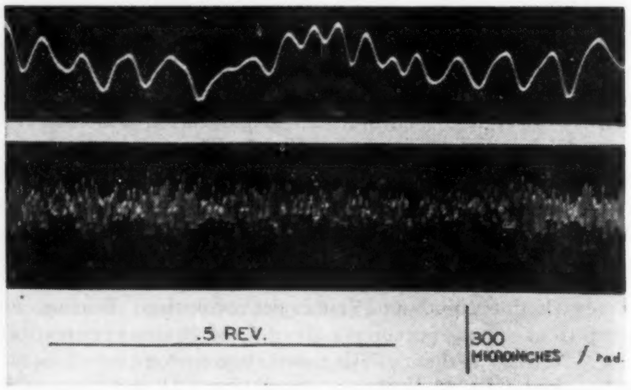
The closely spaced irregularities, 33 to 400 per revolution of the inner race, generate higher-pitched sounds in application.

Accordingly, the two measurement bands were chosen to measure those irregularities of the bearing which would generate ranges of low-pitched and high-pitched sounds. The result of the two-band division is shown in Figs. 10 and 11.

As shown in Fig. 10, the average height of the widely spaced waves is smaller for bearing *a* than for bearing *b*. Whereas, in Fig. 11, the average height of the finely spaced irregularities is greater for bearing *a* than for bearing *b*. Therefore when running, bearing *b* will produce more low-frequency vibration and bearing *a* more high-frequency vibration, even though the total is approximately the same.



(Top) Fig. 10(*a*); (bottom) Fig. 11(*a*)



(Top) Fig. 10(*b*); (bottom) Fig. 11(*b*)

FIGS. 10, 11 OSCILLOGRAMS OF TWO PRECEDING BEARINGS TAKEN AFTER DIVIDING MEASURING VOLTAGE INTO TWO BANDS; FIG. 10 SHOWS CURVE PRODUCED BY BAND MEASURING MOTIONS OF OUTER RACE OF FROM 2 TO 33 TIMES PER REVOLUTION; FIG. 11 IS CURVE FROM DISPLACEMENTS OCCURRING FROM 33 TO 400 TIMES PER REVOLUTION OF INNER RACE

(Note in Fig. 10 that average height of widely spaced waves is smaller for bearing *a* than for *b;* Fig. 11 shows average height of finely spaced irregularities to be greater for bearing *a* than for bearing *b*. In operation, bearing *a* will produce more high-frequency vibration, and bearing *b* more low-frequency vibration.)

The convenient term to use in expressing the width of a frequency band is the octave. The octave is the band width covered by a ratio of 2 to 1 in frequency. For example, the frequency band between 100 and 200 cycles is an octave.

In the hypothetical case of a bearing with equal frequency distribution, any octave would produce the same average voltage, and hence the same meter reading. The average voltage or meter reading produced when the voltage from any two bands is applied to the meter is equal to the square root of the sum of the squares of the individual bands. Let us consider, for example, that any octave of the hypothetical bearing will produce 3 v. If we meter 4 octaves, the total reading will equal the square root of the sum of the squares, or

$$\sqrt{3^2 + 3^2 + 3^2 + 3^2} = 6$$

Thus we see that the same bearing gives us different readings depending upon the band width used. If the unit of measure is to be independent of the band width selected, then the unit must be defined in terms of unit band width.

Referring to our example of the hypothetical bearing, if the voltage read by the meter is divided by the square root of the number of octaves metered, we will obtain the same reading regardless of the number of octaves per band.

Thus the unit we use becomes microinches per radian per octave to the one-half power. For simplification and brevity, we have coined the name of "anderon" for this unit.

Fig. 12 is a curve showing anderons of a typical bearing plotted against irregularities per revolution of the inner race. This also shows average meter readings where the frequency range has been divided into three bands.

The total reading can be split into as many bands as may be found useful. For practical application, it appears that two to five bands are the most useful. (The present model, Fig. 1, uses three bands.) In this way, the relative heights of wide, medium, and finely spaced irregularities can be quickly determined. Information obtained in this way can frequently be utilized in locating and correcting details of manufacture responsible for the irregularities. This selective inspection is also useful in selecting bearings for various applications.

THE ANDEROMETER

Fig. 1 shows the production instrument developed to make these measurements. Since the unit of measurement is the anderon, the instrument is named the "Anderometer" and consists of four units, the spindle, converter, amplifier, and meters.

The inner bearing race fits the spindle with a slip fit and is rotated by the spindle at the proper speed. The outer race is held stationary by hand with the converter in contact with it. A heavy casting with dovetail ways permits adjustment of the converter for various sizes of bearings, at the same time assuring a fixed relationship of converter to spindle and inner race.

The amplifier cabinet contains the amplifier, band-pass filters, meters, and a speaker. This latter enables the operator to listen to the bearing noise, useful in detecting dirt in the bearing and for other short-period effects which are of too short duration to affect the meters.

An attenuator for each meter enables the operator to adjust the amplification for testing bearings of various qualities. The meters are calibrated in percentages of the anderon reading of the attenuator setting.

In operation the instrument is simple. The attenuators are set at predetermined values for the type being tested. The operator slips a bearing on the running spindle, listens to the sound from the speaker, and notes if the meter readings are below the passing limit. Several thousand bearings can be tested daily.

It is recognized that this set of measurements is not a complete description of bearing quality. Nor will it predict performance under all variations of installation, deflection of mountings, etc. The measurements have been found, however, to give a useful production check of over-all bearing quality.

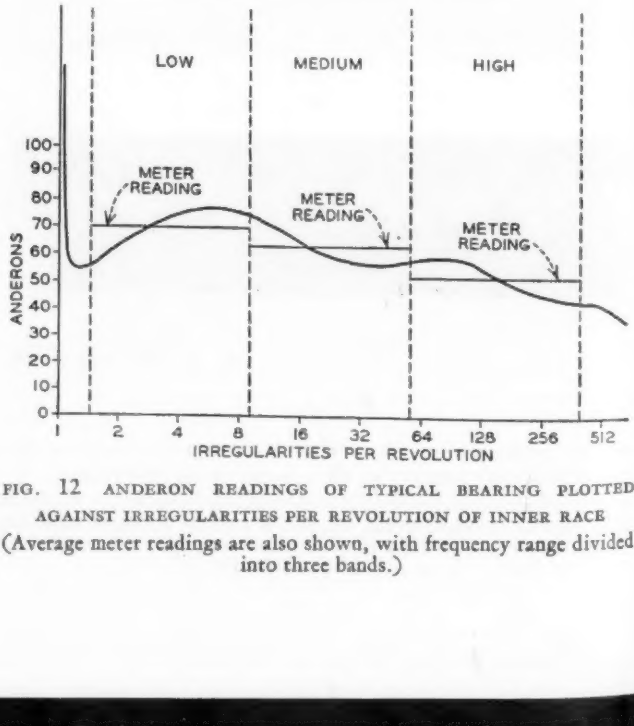


FIG. 12 ANDERON READINGS OF TYPICAL BEARING PLOTTED AGAINST IRREGULARITIES PER REVOLUTION OF INNER RACE

(Average meter readings are also shown, with frequency range divided into three bands.)

FUEL INVESTIGATION *Should* *Precede* POWER-PLANT DESIGN

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THE heavy demand for fuel by our war industries has suddenly forced the realization upon consumers that our national reserves of oil, gas, and solid fuels are not unlimited. Our buying habits, during the period of plentiful production, adequate transportation, and relatively cheap delivered cost are inclined to become somewhat careless. It is hoped that our experience during the present abnormal conditions of demand will bring a new consciousness of fuel values that will prevent the dissipation of our fuel reserves in the future and permit our industries to utilize them in the production of steam at the lowest possible cost.

This paper describes the fuel facts which should be developed prior to the planning of new power plants or the modernization of obsolete equipment; a program which can begin as soon as critical materials are released for civilian needs. The nature and extent of our fuel reserves have been well established under the direction of the United States Bureau of Mines, and it is the problem of the engineers, who are concerned with the utilization of these fuels, to determine what fuel is economically available for the entire life of the new or modernized plant.

"First things first" is an elementary slogan which this author recommends to emphasize the necessity of a complete "fuel investigation" that should be conducted to reveal all of the facts on availability, quality, and delivered cost, in order to forecast a competitive steam-production cost, prior to the design and installation of new steam-generating equipment.

The fuel investigation in its broadest sense requires a complete study of all fuel resources. Because of the fact that there are tremendous reserves of bituminous coal, it is generally recognized to be the fuel of the future and, for this reason, this paper will only cover the procedure to be followed in determining the range in quality of bituminous coal which should be utilized by the new plant. In most cases, bituminous coal represents the best fuel value that will be available.

This "fuel investigation" does not consist of a simple tabulation of the replies received from a blanket inquiry concerning the current price or current availability of coal for the proposed plant. The prices obtained today, under the wartime demand and controlled by O.P.A. regulations, cannot be indicative of the relative utilization value. Price relationships that stand the test of time are governed by the laws of supply and demand and by competitive performance. The fuel investigation must go much deeper than a price and quantity inquiry. Many facts must be assembled which are not readily available to the consumers of coal and to the manufacturers who provide the equipment, as there are few data in the usual reference works. Therefore it will also be necessary to obtain the advice of specialists in combustion, coal production, and fuel transportation to establish the facts which must be considered in selecting the equipment, the fuel, and the site of a new power plant. The quality and characteristics of the bituminous coals economically available should then be used as the basis for the design of the combustion equipment that will use these coals efficiently and produce steam at a competitive cost.

Contributed by the Fuels Division and presented at the Semi-Annual Meeting, Pittsburgh, Pa., June 19–22, 1944, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

The first step is to obtain complete information on all of the grades of coals, which are competitively available.

COMPETITIVE COALS AVAILABLE

The geographical location of industrial communities in the United States is usually determined by the presence of some basic raw material, or because of ready access to low-cost transportation facilities. Bituminous coal is of primary importance to industries for the generation of heat, light, and power, and is readily accessible by excellent rail-transportation facilities and low-cost water-borne movement throughout the eastern half of the United States. Undoubtedly, coal has been a major factor in determining the industrial concentration in this part of the country. Large industrial communities do not develop unless they have ready access to this basic fuel. We see many examples of what happens to an entire community when its basic raw material is exhausted. The competitive position of its industry is impaired because of excessive production costs and high transportation costs. It naturally follows that, in designing a power plant, the equipment should be designed to use a range of quality rather than to be restricted to the use of a particular coal or one with limited reserves. Communities must be competitive. Industries must be competitive, and their power plants should be competitive. Low-cost steam may be a major factor in determining the ability of a company to pay dividends to its stockholders.

In giving consideration to the coals which are competitively available, a great deal of information can be obtained from the professional papers of the United States Geological Survey of the Department of the Interior, and from the Department of Mines of the producing states. The coal fields of the United States are divided into six geological provinces, and a fund of information is available as to their location, extent, characteristics, and quality. For purposes of this paper, we shall discuss only the coal fields of the Eastern Province and the Interior Province, because it is from these fields that the majority of the coal is shipped to our industries in the East and Central West.

The coal-producing districts of these provinces, as established under the Bituminous Coal Conservation Act of 1937, are listed in Table 1, together with their 1942 production, representing over 80 per cent of the total production of bituminous coal for that year.

TABLE 1 COAL-PRODUCING DISTRICTS OF EASTERN AND INTERIOR PROVINCES

	Tons
District No. 1—Eastern Pennsylvania	57877000
District No. 2—Western Pennsylvania	88144000
District No. 3—Northern West Virginia	38991000
District No. 4—Ohio	34600000
District No. 5—Michigan	320000
District No. 6—Panhandle	5324000
District No. 7—Southern Numbered 1	64427000
District No. 8—Southern Numbered 2	119852000
District No. 9—West Kentucky	13240000
District No. 10—Illinois	63750000
District No. 11—Indiana	25470000
District No. 12—Iowa	2990000
Total	514985000

Transportation Costs. Each of the producing districts, listed in Table 1, is divided into a large number of "freight-origin groups." Generally speaking, all of the mines on the same railroad in a freight-origin group take the same rate to a given destination although all delivering railroads may not have the competitive freight rate from a freight-origin group to a particular destination. It is therefore desirable to select a power-plant site on a railroad which has competitive rates from the maximum number of freight-origin groups.

A large industrial city such as Chicago normally receives coal from at least ten of the twelve coal-producing districts mentioned, and from undoubtedly more than thirty freight-origin groups. The actual freight rate paid will vary from less than $1 to over $3 per ton. Cost of transportation to any destination is a most important factor in determining whether a coal region, a producing field, or a specific mine can be considered competitive for the power-plant site selected.

All delivering carriers will be glad to supply the freight-origin groups normally shipping to any destination, together with the freight rates applicable from all originating mines. These data will disclose a wide spread in the cost of transportation which has been shown to be over $2 for Chicago. It is obvious that the coal shipped on the high freight rate must have some compensating property such as low production cost, excellent quality, or special characteristics, if it can be considered as competitive with such a large transportation differential against it.

During recent years, our interior waterways have been greatly developed for cheap transportation of water-borne coal. The selection of power-plant sites must also take into consideration coal movement by river, lake, and tidewater, so that transportation costs may be reduced to the lowest possible level.

Production Costs. Statistics, compiled under the Bituminous Coal Conservation Act, reveal a spread in the average production cost for the first quarter of 1943, as between the twelve districts previously described, of over $2.70 per ton. The lowest average cost of any district was slightly over $1.50 and the highest cost was over $4. It is immediately apparent that production costs must be considered in forecasting the competitive relationships between coal-producing districts during the probable life of any new power plant.

Under the system of free enterprise existing in this country, we should be safe in assuming that the selling price f.o.b. the mines is very closely related to the production cost of the coal. During the public hearings held for the establishment of minimum prices, under the 1937 Conservation Act, the cost of individual mines in the same seam, and in the same district, frequently showed a spread in production cost of more than $1 per ton. This great spread in cost of production (1) as between districts, and (2) as between mines, is of major importance in determining the future relationship between the selling prices of the coals, and forecasting whether the producers of these coals will be able to stay in business during a normal competitive market. Knowledge of coal-production costs is therefore essential in long-range fuel planning.

Delivered Cost. The fuel investigation must consider the delivered cost per million Btu for a basic comparison of relative values. Well-designed steam-generating equipment today can be expected to utilize the average coal efficiently, regardless of the special characteristics, so there seems to be no point in planning to use a premium coal. The latter can be defined as one with high chemical quality and excellent physical or performance characteristics which permit of wider and more diversified application, although selling at market prices that cannot be justified in competition by the delivered cost per million Btu. It would therefore seem undesirable to plan on a premium coal. However, the delivered cost per million Btu should be emphasized and used as a criterion of value in the matter of fuel selection, and the equipment manufacturer should be required to design accordingly. In normal times, the fuels with difficult performance characteristics bring prices lower than are justified by their delivered cost on a heat-value basis. It is only during periods of firm demand, such as we now have in wartime, that fuels with limiting characteristics will bring a price comparable with their relative utilization value.

Modern Mining Methods. In the past few years, the application of modern mining methods has increased tremendously. The advance has been somewhat retarded during the war because of shortages of vital materials, but the postwar period will, undoubtedly, cause many of the high-cost hand-loaded mines to shut down because they cannot compete with the lower-cost mechanized mines. Some coal seams are thin, irregular, and not adaptable to high-speed mechanical mining, so that mines with these conditions will be unable to maintain competitive production costs in the future. Mines operating in coal seams which are suitable for mechanized equipment, undoubtedly will have the best opportunity to sell at relatively lower prices in any market.

Exceptionally large consumers of bituminous coal may find it profitable to arrange with a producer to take the entire output of one or more mines. The mine should be completely mechanized to obtain low-cost operation, and mechanical cleaning equipment may be installed to remove extraneous impurities and provide uniform quality. Long-term arrangements or contracts of this type are usually made on the basis of the operating cost plus a profit margin. In a deal of this kind, the operator is usually satisfied with a low profit margin because he is assured a backlog of regular production, and the consumer is satisfied because he has a guaranteed source of supply at a price which is unaffected by market and seasonal variations.

One thought to remember in connection with the installation of mechanical cleaning equipment is that the cost of such cleaning should not be greater than the increased utilization value to the steam coal user. Particularly on long-term contracts to one consumer, a cleaning cost of 10 cents cannot be justified when the improvement in quality increases the delivered Btu by only 5 cents over raw coal. This argument, of course, is only appropriate when the competition of the coal is limited and the transportation costs are relatively low.

The foregoing facts indicate that, with any long-range fuel planning, proper weight must be given to the physical and financial ability of the producing company to employ modern mining methods with mechanical cleaning facilities, and thus assure competitive costs and competitive values for the future.

Market-Price History. The overdevelopment of production facilities for bituminous coal in the first world war caused subsequent market conditions that depressed the price of coal to a low level at which this great basic industry lost money for an entire decade. Relative prices during such a period correspond more nearly to the competitive utilization value. The premium coals, of course, have the advantage because they have a wider market, and the very poor-quality coals can only be used locally. The other coals of good quality, but difficult to use because of some restricting characteristic, are really depressed in price below their competitive utilization value during this weak-market period. It is from this latter group of coals, which comprises the major tonnage of the nation's resources, that there is the best opportunity for economical long-range purchasing. A study of the price relationship between several coals, in various sizes, for several years past usually reveals relative production costs and can be very helpful in selecting the best coal value for future use.

Unmined Reserves. When a coal is selected for a new power plant, one must be assured that the particular coal or grade will be readily available for a long time. Some of the mines, particularly in the high-fusion low-volatile coals, will be exhausted within the next few years. Tremendous reserves are available in the low-fusion high-volatile coals, and these facts will be brought to light in the fuel investigation, which

has been recommended. Reserves must therefore be considered.

Relative Availability. Users of fuel oil and specialty coals have discovered during this war that these specialty fuels are conscripted first for war service. The specialty coals suitable for by-product and metallurgical use have been taken away from the steam plants. Our experience in this wartime boom market should cause us to be a little cautious in our future designs, so that the plant may have sufficient flexibility and capacity to carry the necessary load with a normal-quality steam-grade fuel. Specialty coals should be preserved for those plants which cannot use ordinary grades.

Fuel Conservation. Fuel resources have been so plentiful in this country that they have been lavishly dissipated. Our experience in this war points to the necessity of some future conservation plans, particularly for the production and utilization of oil, and probably a plan for the coal industry which will protect it from the ills of excess productive capacity. Regardless of the form which these conservation plans may take, one can be safe in building the new power plant using the basic economic facts developed in the fuel investigation.

PROSPECTIVE FUEL SUPPLY

Primary Selection. The analysis of all of the facts developed in the fuel investigation will point to one or more producing regions or freight-rate origin groups from which one can expect to receive the best fuel value for long-range purchasing. Usually the primary selection will include a number of mines from the same seam producing coal of substantially the same quality. The characteristics of this coal should then be used in setting up the coal specification controlling the design of the plant.

Secondary Selection. Availability of one or more alternative sources of supply always permits competitive purchasing, and one of the objectives of the fuel investigation should not only be the selection of the primary coal, which is the best value, but also to set up a secondary coal source of supply, probably from a different seam and a different region. This secondary coal can then be purchased for competitive reasons or when market conditions make it a better value than the primary source.

The coal specification, under which utilization latitude is provided in the design of the combustion equipment, should be prepared to include the quality and characteristics of both the primary and secondary coals.

COAL SPECIFICATION

For Design. The fuel study will reveal that the majority of the coals from a certain seam in a particular region will be produced in various sizes, and that one or more sizes will provide the lowest cost per million Btu. For pulverized fuel use $^1/_4$ in. $\times$ 0, $^3/_8$ in. $\times$ 0, $^3/_4$ in. $\times$ 0. Slack sizes will probably be better values than $1^1/_4$ in. $\times$ 0, or 2 in. $\times$ 0 nut slack sizes. Because of seasonal demands, it may be important to design for the utilization of a maximum size of 2 in. $\times$ 0. In the present war emergency, a plant which can use run-of-mine size has maximum purchasing flexibility, and undoubtedly many steam plants in the future will find run of mine the best value. The margin between the price of slack and run of mine is diminishing every year as combustion and preparation equipment improves, so that the large steam plant of the future should install crushing equipment for the final sizing of the grades and sizes, which represent the best values that may eventually be run of mine.

Chemical Quality. The proximate analysis to be considered should represent the average quality of the coal to be supplied. For the modern plant, this quality data, particularly the Btu, is the yardstick of utilization value. This analysis is essentially an average of many samples taken from current shipments. The proximate analysis should indicate the moisture, as shipped, the volatile, fixed carbon, ash, and sulphur. The Btu and "ash-softening temperature," should also be included with the proximate analysis.

All coal seams vary in chemical quality, and even in the same location there may be a wide variation. The producer may compensate for these conditions, if the cost is not prohibitive, by blending the various grades from the reserves accessible to the mine and by so doing can ship quite a uniform product, the quality of which varies within rather narrow limits. With careless mining, the average quality will give no indication of the variables which will be encountered as this coal is burned. The combustion equipment must have sufficient latitude to utilize the product received, and it is therefore very important to know the range (maximum and minimum) of the moisture, ash, Btu, sulphur, and ash-softening temperature, in order that equipment may be designed accordingly.

Moisture. Mechanized mining requires the spraying of water or some dust-settling agent on the bars of the cutting machine at the mining face, in order to minimize the explosive hazard. The quantity required will vary with the gaseous conditions at each mine and also with the physical characteristics of the coal. Moisture will therefore be higher from the mechanized mine than the old mines, which were hand-loaded. The moisture, as shipped (an average can be specified by the producer) will include the natural body or inherent moisture, plus the extraneous or surface moisture, which will vary due to geological conditions and thickness of overburden; plus the additional extraneous which is sprayed at the face. The moisture, as fired, includes the moisture as shipped, plus that which may be added during transportation, handling, or storage. The moisture, as fired, is the figure to be taken into consideration in the design of preparation, handling, and combustion equipment, at the power plant.

Physical Characteristics. It is desirable for the designer to know the "friability" of the coal, or its resistance to degradation in handling, so that conveying and handling equipment may be properly designed. The dust nuisance is always objectionable in the modern plant, and dusttight handling equipment will permit the use of the small sizes which are usually the best values.

The "grindability" of the fuel selected indicates its relative ease of pulverization, and is a determining factor in establishing pulverizer capacity. Liberal capacity will permit the use of the harder-structure coals, whereas limited capacity necessitates the purchase of high-grindability soft-structure coals, which may not be the best value available.

Size Consist. Old or obsolete plants frequently require specially sized coals for satisfactory performance. When the fines ($^3/_8$, $^1/_4$, or $^1/_8$ in. $\times$ 0 slack) must be removed to compensate for a design or performance weakness, the plant requires a premium coal. The most economical sizes are the natural sizes screened from mine run. When designing combustion equipment, it is important to have available a screen analysis. These data, which are known as the "size consist," describe the proportion of the various size increments which exist in a normal or natural preparation and should be known to the equipment manufacturer, so that designs may be provided to compensate for segregation and burn these natural sizes properly.

Storage Characteristics. Storage characteristics are particularly important to those plants with seasonal or intermittent fuel deliveries. Plants requiring storage facilities and particularly those receiving water-borne coal should always design their storage plants to handle the coal selected so that there will be no loss from spontaneous heating.

Performance Characteristics. The action of the coal during the combustion process is usually less critical in the well-designed modern combustion equipment than in the average plant. For designing purposes, however, it is desirable to know the coking or caking characteristics of the fuel to be used, the clinkering or slagging tendency, under furnace conditions, demanded by modern high efficiency practice; the corrosive characteristics of the gases of combustion, and also the ignition or flame characteristics of the coal.

The designing coal specifications for the new plant must therefore include all of these factors representing the quality and the physical and performance characteristics of both the primary- and secondary-coal selection. When this basic information is available, it is the author's considered opinion that reputable manufacturers and engineers will be able to install power-plant equipment to give optimum performance and the lowest steam cost throughout their useful life.

SELECTION AND PURCHASE OF COMBUSTION EQUIPMENT

In the selection and purchase of combustion equipment, it is usually desirable to fix the responsibility with one firm for the construction and complete operation of all the component equipment to be installed in a new power plant. There must be complete co-ordination in the design of the separate pieces of equipment, which must handle coal in its travel through the plant and in the final preparation for utilization.

The combustion equipment, of course, is the most important consideration, and then, finally, there must also be a satisfactory system for the disposal of the refuse. Any equipment which is unsatisfactory or inadequate constitutes a "weak link" in this entire chain and may upset all of the basic plans for the utilization of the best fuel values. This over-all responsibility should only be given to a competent and responsible engineering firm or manufacturer of combustion equipment, who has a good background of experience in the design and erection of plants in the capacity range which is required. With this precaution, the consumer can expect to secure the latest equipment developments and the full advantage of all of the facts developed by the fuel investigation and long-range planning.

The purchase of power-plant and combustion equipment because of its low first cost is a very weak and shortsighted policy. Equipment which will permit reasonably wide latitude in fuel purchasing must be liberally designed and, if the range of coals selected after the fuel investigation is to give operating satisfaction, the manufacturer must not be required to cheapen the installation in order to meet price competition. It is, of course, obvious that any premium in the initial investment must be justified by the economies effected in the operating results.

With a good background of fuel facts developed by the fuel investigation, equipment can be selected that will operate with a minimum outage, thus providing maximum capacity per dollar invested. Liberal capacity should be provided to carry anticipated steam demands with the primary or secondary fuels, so that there will be no necessity for purchasing premium coals.

When providing for the utilization of coals which are difficult to burn, every precaution must be taken so that the equipment selected will be designed to operate with a low maintenance cost. Proved performance results, under similar conditions, are the best guarantee that there will be complete satisfaction with the new installation. The ability to burn efficiently the coals available, which may vary widely in quality and performance characteristics, is an important point to consider in evaluating combustion equipment.

A purchase because of low first cost, as just stated, is an inexcusable error. It is almost as bad to buy because of high thermal efficiency. It is frequently desirable to sacrifice efficiency for economy. The fundamental consideration must be "dollar efficiency" which is the over-all cost per thousand pounds of steam generated.

Simply stated, this means that the entire power-plant problem should be placed in competent hands, in order that the best results may be assured. These results will then justify the cost.

COAL FOR EXISTING PLANTS

The coal specifications developed for the purchase of coal suitable for the combustion equipment of the existing plant can only be as liberal as the weak link in the old plant. As previously stated, this weak link may be in the coal handling, crushing, or sizing, or in the combustion equipment itself. Some factor in the coal specification must limit the selection to some coal that will give complete satisfaction in spite of the weakness in design.

Any purchase specification issued by the buyer should be sufficiently flexible to permit the substitution of sizes under abnormal market conditions. It will undoubtedly become a practice in the near future for industrial buyers to submit equipment and performance information with their inquiries, so that producers can supply the proper coal and size which he has available to meet conditions that will be encountered in that plant.

In the present war emergency, some purchasers have found it impossible to buy the premium coals necessary for satisfactory performance, and, in such cases, they have been compelled to modernize so that more readily available coals can be burned. The lessons learned under present conditions will, undoubtedly, cause the modernization of a great many plants, as soon as critical materials and equipment can be made available.

The coal-purchasing specification must be more elaborate and more limiting for those plants with inadequate or obsolete equipment. It is good practice to provide the prospective supplier with proximate-analysis limits, the range in Btu content, and the ash-softening temperature, which will cover the grades of coal that have been found acceptable. There should also be some flexibility as to sizes which can be used, because performance characteristics vary with quality and size. Uniformity of quality is a major factor controlling coal acceptability for the old plant but is not usually in the buyer's specification. Average quality will not guarantee satisfaction.

Buying coal is just like buying new equipment, the best recommendation is the "case history" or factual record of satisfactory performance of the coal on similar equipment and under comparable conditions. "Specifications" should never be used as a substitute for confidence in the purchase of coal, and satisfactory performance should always justify deviation from specification.

If the present plant is not competitive in operating cost, make plans now for postwar modernization. Go through the successive steps recommended in the *fuel investigation*, which precedes new power-plant construction, and utilize every fact developed to the maximum extent possible for a modernization program that will assure a competitive steam-generating cost.

Pilotless Aircraft

DURING the past week, "Southern England" has been experiencing intermittent enemy attacks by means of pilotless aircraft, fitted with an explosive charge in the nose and launched from positions on the French coast. According to an Air Ministry bulletin, these aircraft are jet-propelled and are launched from a ramp, probably with the aid of a rocket. The fuselage is 21 ft 10 in. in length, with a maximum width of 2 ft, $8^1/_4$ in., and the over-all length is 25 ft, $4^1/_2$ in. The wing span is 16 ft, and the jet propulsion unit is mounted above the fuselage and rudder. The range of the type in use at present is about 150 miles and the speed in level flight is between 300 miles and 350 miles an hour. The explosive, equivalent to that in a 1000-kg German bomb, is carried in a thin casing attached to the front of the fuselage. The fuel used is petrol and the exhaust from the jet-propulsion unit produces a distinctive intermittent noise, due to a series of explosions. The aircraft is constructed mainly of steel and is colored dark green on top and light blue on the under surfaces—the usual German camouflage. It is not radio-controlled, as early rumors suggested it to be, but is held on its course by an automatic pilot, set before take-off. The fact that the enemy was contemplating the use of such a weapon was no secret, though the intended date of the attack may have been.—Engineering, June 23, 1944.

COAL SEGREGATION *in* BOILER PLANTS

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COAL segregation in boiler plants is a cause of fuel waste and increased maintenance, and it limits maximum steam output. Therefore, it is a subject which should be given careful consideration in order that boiler plants may produce maximum results. Whenever coal is moved there is a tendency to separate the coarse from the fines or to mix the coarse with the fines. What actually takes place depends upon the conditions surrounding the movement of the coal.

This paper will try to explain coal segregation, its problems, and their solutions. It will therefore give to boiler-plant operators the basis for study of their own plants with the end in view of making improvements therein. It is felt also that an understanding of the problem of coal segregation will benefit consulting engineers in their design of future plants.

This discussion is limited to coal segregation as it is experienced in steam-boiler plants; however, the principles are fundamental and they may be applied to any place where coal is handled. Segregation exists in many other places, and although this paper is not intended to cover any other material than coal, it still may prove of value as a starting point for the solution of problems involving other materials. For such problems engineers should bear in mind that coal particles are fairly alike in shape and density whereas other materials may have more widely varying properties. This is particularly true where mixtures of materials are employed.

WHAT IS SEGREGATION?

According to Webster, to segregate means, "to separate from a general mass and collect together or become concentrated at a particular place or in a certain region." As applied to coal in boiler plants, segregation means to separate the larger particles of coal away from the finer particles. If this segregation continues into the furnace, combustion will be found to be irregular because of the different burning characteristics of the different sizes of coal. Irregularity of combustion results in lower efficiency, higher maintenance, and lower maximum capacity.

Nonsegregating, which of course is the opposite of segregating, means to keep in a mixed condition. Inasmuch as coal is always segregating or mixing as it is handled, transported, and used, it is extremely difficult to have coal completely mixed at all times. Therefore, some definition of nonsegregating equipment as applied to boilerhouse equipment is needed.

In our work we have defined nonsegregating equipment, as applied to coal-handling equipment in boiler plants, to mean that type and arrangement of equipment which puts the coal into the stoker hopper of a stoker or into a feeder of a pulverizer in a thoroughly mixed condition or in such a condition that the firing results are uniform. The fact that a piece of equipment operates well in one case is not proof that it is nonsegregating, because the degree of segregation and the effect of that segregation on the fire varies considerably with the characteristics of the fuel and stoker. The equipment, if properly installed, must produce satisfactory results with any coal to be nonsegregating.

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EFFECT ON STOKER OPERATION

Coal segregation adversely affects stoker operation, because the ignition of coarse coal proceeds at a different rate from that of fine coal; then too the resistance of the fuel bed to the flow of air varies according to coal size. Those parts of an underfeed or chain-grate stoker covered with coarse coal burn faster than those parts of the stoker covered with fine coal. As a result, the fire burns shorter where the coarse coal exists, and hence a portion of the stoker becomes exposed except for ash. Through that part of the stoker, air passes without having an opportunity to combine with the fuel. This air picks up heat from the furnace which it carries to the stack. This is a loss of heat. Also this exposed portion of the stoker becomes overheated and burning of the stoker iron follows.

In those parts of the underfeed or chain-grate stoker where the fine coal exists, combustion proceeds at a slower rate, which means that it is incomplete when the stoker dumps the ash. The unburned portion of the fuel bed is therefore dumped into the ash pit. This condition results in a high combustible content in the ash. In some cases coal segregation may also cause clinker formation due to the fact that some sections of the fire burn at higher temperatures than others. This is particularly true where low-fusion-ash coal is burned.

Uniform size distribution of fuel is also important on a spreader stoker. If for some reason the distribution is not uniform, a clinkering tendency will be noted wherever there is piling. Adjustment in the speed of the flipper is provided for changes in size of fuel. When the fuel tends to run large, it must be slowed down, and when it tends to run fine, it must be speeded up. Where more than one feeder is required for a boiler, it is customary to run all feeders from a single line shaft, which means that no individual unit can be varied in speed from the others. They all go up and down together. Therefore, uniformity of fuel to the various hoppers is important, otherwise one might be throwing too far and the other not far enough. Segregated coal feed on spreader stokers would thus result in loss of combustion efficiency and clinkering.

Coal segregation causes higher maintenance of furnaces, because the irregular firing conditions allow certain parts of the furnaces to be at higher temperatures than others. Gas velocities also vary across the furnace. Damage due to these variable conditions is severe in the case of refractory arches over chain grates.

In the case of pulverized coal, chute segregation is of no importance, but segregation caused in a bunker, which changes the size of the coal from minute to minute, does change the grinding capacity of the mill. This is particularly true when there is considerable surface moisture, inasmuch as the moisture affects the mill-grinding capacity of fine coal more than that of large coal. Moisture combined with the fines causes a sticky condition which affects the rate of feed of the feeder, or which may cause coal stoppage.

Because it is very difficult to make clear the exact costs of coal segregation and the dollar savings that will result because of its elimination, many plants tolerate bad conditions. The benefit to be derived from the elimination of segregation depends upon how bad the conditions are in the plant before im-

provements are made. It is for this reason that the author feels reluctant to quote the improvement in results that has been obtained in some plants. Suffice it to say, however, that improvement in conditions has in most cases proved to be very much worth while from the economic point of view.

CAUSE OF SEGREGATION

Just why does coal segregate? The forces which act on pieces of coal as they move from one point to another vary according to their size, and therefore the direction of motion is different for each size. Illustrations of coal segregation are presented herewith, not with the idea of condemning one type of equipment and recommending another, but rather to point out how segregation occurs in each case, how to recognize the effects of such segregation, and what to do about it. When coal segregation in a boiler plant is considered, every step from the car to the inside of the furnace must be studied. Segregation caused early in this process often cannot be subsequently corrected. Most of the causes of coal segregation in boiler plants are due to the equipment installed in the plant, or to the arrangement of that equipment. Operation is seldom the cause of coal segregation.

In order to get an understanding of coal segregation, let us analyze the case of the typical flat chute such as has often been used to feed stoker hoppers. If a flat plate were inclined to the horizontal as shown in Fig. 1, and a piece of coal were placed at its upper edge and then released, it would follow the steepest slope down the surface of the plate as indicated.

A number of such pieces of coal released successively from the same starting point would form a pile at the bottom, as shown in Fig. 2. The coarse coal would roll over this pile, away from

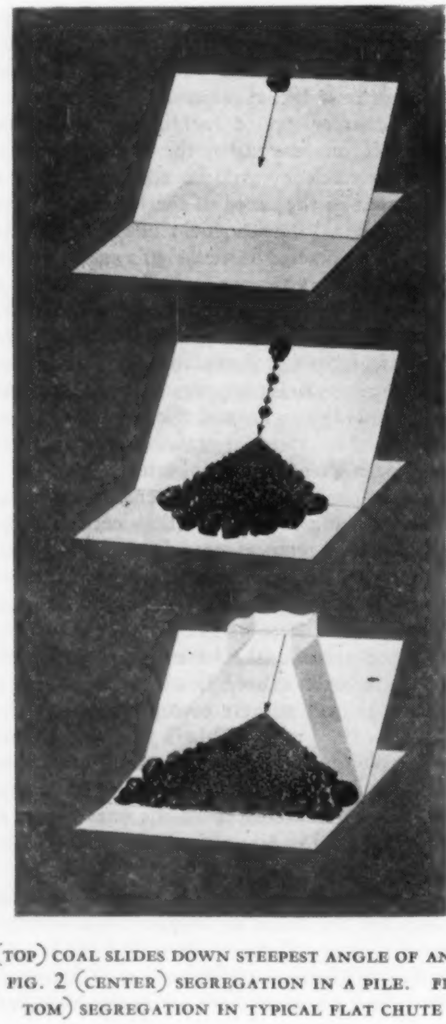


FIG. 1 (TOP) COAL SLIDES DOWN STEEPEST ANGLE OF AN INCLINED PLANE. FIG. 2 (CENTER) SEGREGATION IN A PILE. FIG. 3 (BOTTOM) SEGREGATION IN TYPICAL FLAT CHUTE

FIG. 4 A COARSE-COAL STREAK DOWN CENTER OF CHAIN GRATE CAUSED BY JUNCTION OF TWO FLAT CHUTES

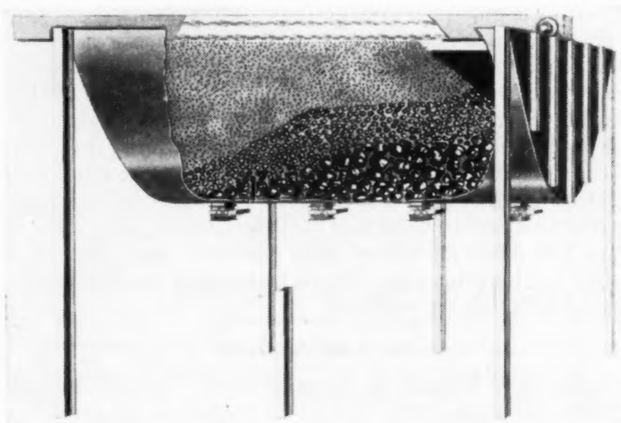
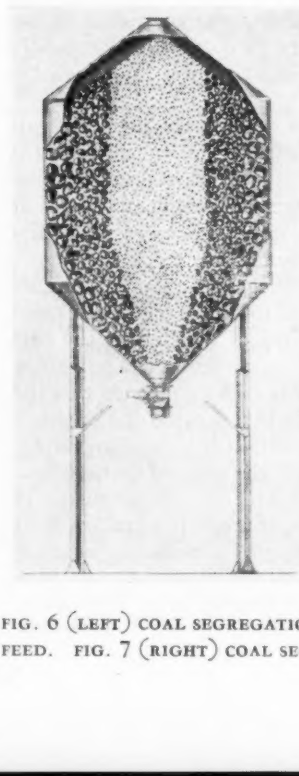


FIG. 5 SEGREGATION IN COAL BUNKER FED BY FLIGHT CONVEYER WITHOUT TROUGH



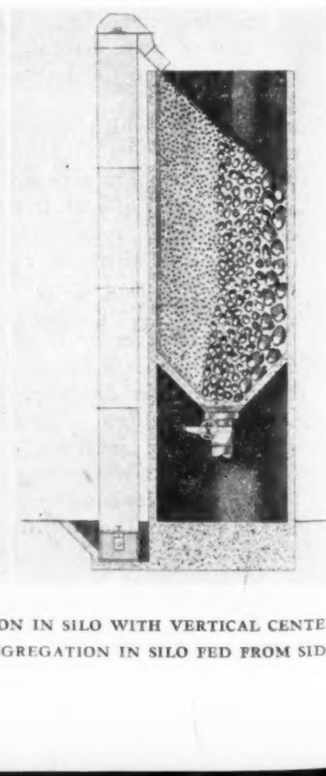


FIG. 6 (LEFT) COAL SEGREGATION IN SILO WITH VERTICAL CENTER FEED. FIG. 7 (RIGHT) COAL SEGREGATION IN SILO FED FROM SIDE

the center of the plate, while the fine would sift through the coarse coal and remain at the center.

Two side guides could be added without changing the tendency for the coarse coal to roll and fine to sift. The addition of a second plate placed parallel to the first, as shown in Fig. 3, would form the usual straight fan-shaped chute. If two such flat chutes were to be installed on a stoker hopper, there would be coarse coal down each side and down the center of the stoker. Fig. 4 shows the coarse-coal streak on a chain grate which results from such an arrangement.

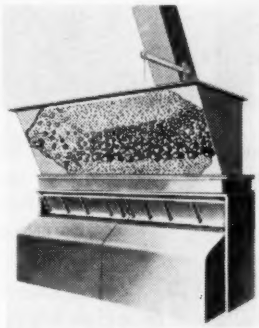
The amount of coal segregation in any installation depends upon the kind of coal, the size distribution, the moisture, the velocity, and the size and shape of the passageways through which the coal flows. A number of illustrations are presented herewith in order to indicate what happens under various conditions. It is not possible to indicate the quantitative amount of segregation that will result with the arrangements as shown. This will account for the fact that a few installations of these equipment arrangements are apparently operating satisfactorily, whereas, under somewhat similar conditions with the same arrangements, results are often very bad.

ILLUSTRATIONS OF SEGREGATION

In Fig. 5, we show coal segregation as it will exist in the coal bunker fed by a flight conveyer without a trough. The conveyer fills the left end first. A pile is formed, the top of which moves toward the unfilled end. This method puts the coarse on the right-hand side of the illustration and the fine on the left-hand side.

In the case of the steel silo with a vertical center feed, Fig. 6, it will be found that fine coal collects in the center of the silo and the coarse will distribute itself around the periphery. When coal is withdrawn from such a silo, fine coal comes out first followed by a mixture, which progressively becomes coarser.

In the case of a concrete silo, as shown in Fig. 7, it will be found that a fine-coal core exists on the side near the elevator and the coarse material exists on the side away from the elevator. As coal is withdrawn from such a silo, it will be found that the coarse coal remains on the right-hand side of the outlet downspout or chute and fine coal on the left-hand side. If coal from such a bunker is fed to a stoker hopper, whose long dimension is parallel to the plane of the illustration, it would be found that the coarse material would practically all exist on the right side of the stoker hopper and the fine coal on the left side. Such an installation would result in a very poor fire.



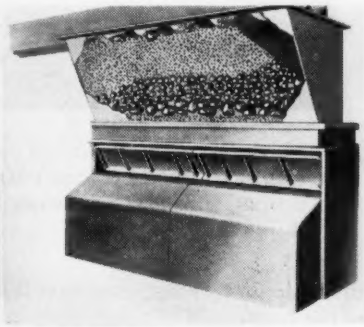


FIG. 12 (LEFT) SEGREGATION IN STOKER HOPPER EXTENSION CAUSED BY INFREQUENTLY OPERATED WEIGH LARRY
(Larry moved from left to right.)

FIG. 13 (RIGHT) SEGREGATION IN STOKER HOPPER EXTENSION CAUSED BY INTERMITTENTLY OPERATED SCREW CONVEYER

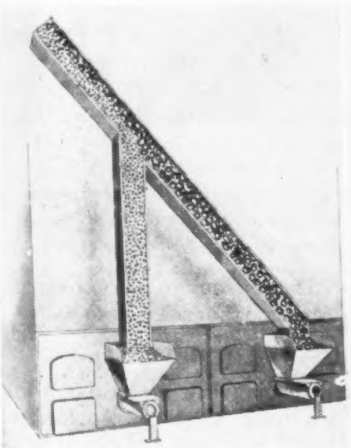


FIG. 9 TWO STOKERS FED WITH SINGLE LATERAL DOWNSPOUT

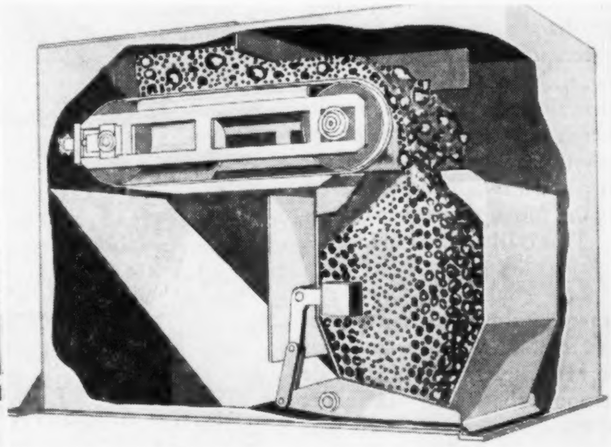


FIG. 10 SEGREGATION IN WEIGH HOPPER OF COAL SCALE

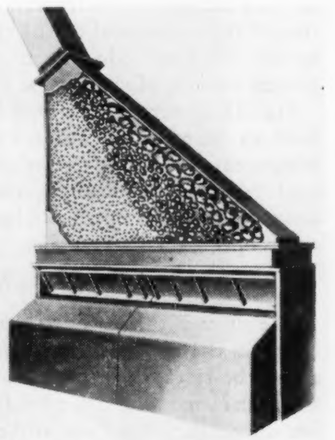


FIG. 11 SEGREGATION IN FLAT CHUTE FED FROM LEFT-HAND SIDE

FIG. 8 SEGREGATION IN AN INCLINED DOWNSPOUT

On the other hand, if the long dimension of the stoker were perpendicular to the plane of the illustration, and were on the right side, then the coarse material would find itself next to the boiler, and the fine material on the side away from the boiler. Fuel so segregated causes little or no difficulty in burning.

When coal slides down a sloping downspout, the coarse coal gradually rises to the top of the downspout and the fine coal sinks to the bottom. Fig. 8 illustrates this condition. Trouble exists in many installations of two single-retort stokers because of this fact; Fig. 9 shows such an installation. Inasmuch as the fine coal settles to the bottom of the downspout, the right-hand stoker hopper receives the coarse coal whereas the left-hand stoker hopper receives the fine coal.

Fig. 10 shows segregation as it takes place within the typical apron-feed hopper scale. The coal slides off the head pulley of

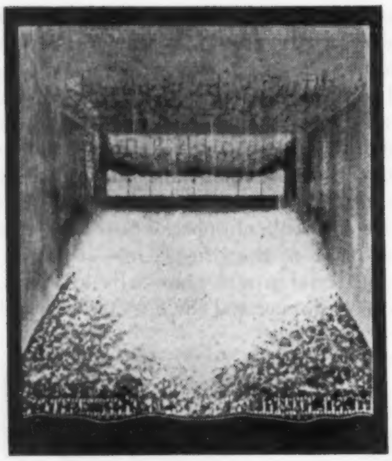


FIG. 14 FIRE RESULTING FROM USE OF TYPICAL FLAT CHUTE; COARSE COAL AT SIDES, FINE COAL AT CENTER

FIG. 15 FIRE RESULTING FROM COARSE COAL ON ONE SIDE AND FINE COAL ON THE OTHER, SUCH AS RESULTS FROM EQUIPMENT SHOWN IN FIG. 11

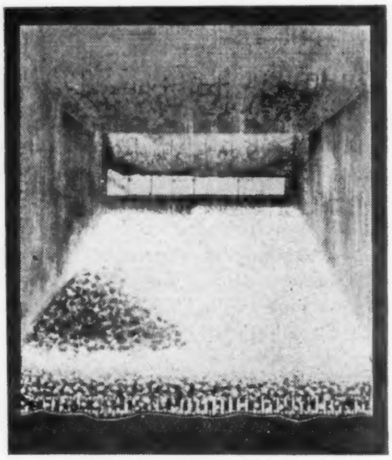


FIG. 16 FIRE RESULTING FROM COARSE COAL SEAM RUNNING PARTLY ACROSS STOKER, SUCH AS RESULTS FROM EQUIPMENT OPERATED AS IN FIGS. 12 AND 13

the feeder in such a manner that it throws the greatest amount of the coarse coal to the right-hand side of the weigh hopper. In the event the coal scale is installed with the feed belt parallel to the stoker hopper, then coarse coal will be at one end of the stoker hopper and fine coal at the other. But if the coal scale is installed with its feed belt running toward the boiler front, then the coarse coal will be on the boiler side and the fine coal will be on the aisle side and no trouble will be experienced.

Fig. 11 shows a flat chute feeding a stoker hopper which has its inlet flange on the left side. This design puts a large proportion of the coarse coal on the right-hand side and the fine coal on the left-hand side. Such an eccentric flat chute causes a greater amount of segregation than the center-feed flat chute.

Fig. 12 illustrates the type of coal segregation that results from an infrequently operated weigh larry. This type of operation causes a coarse-coal seam that runs across the flow of the coal. A similar coal-segregation pattern is caused by a screw conveyer which is installed along the top of the stoker hopper and is operated only periodically. This is illustrated in Fig. 13.

APPEARANCE OF FIRES WITH SEGREGATED FUEL

The effect of the segregation caused by the simple fan type of chute on the fire is illustrated in Fig. 14. Note the short fire along the sides of the stoker and also the erosion of the side walls and arch where the combustion rate is high. The short fire uncovers part of the stoker, allowing excess air to pass through and the stoker iron to be damaged. Also note the long fire in the center where unburned fuel is dumped into the ash pit. Similar fires are the result of a single downspout, a weigh larry, or swinging spout which is allowed to stand with free discharge in the center of the stoker hopper.

Fig. 15 shows the type of fire that results when the coarse coal is all on the one side and the fine coal on the other, such as would be the case if the arrangement of equipment, as shown in Fig. 11, were employed.

With the type and operation of equipment, shown in Figs. 12 and 13, segregation will result in the fire as shown in Fig. 16. These cross-holes in the fire will have the same time frequency as the frequency of operation of the stoker hopper filling the equipment. Many operators do not recognize this type of segregation since it is periodic and not of the streak type. In many cases it can be eliminated or reduced by more frequent filling of the stoker hopper.

ELIMINATION OF COAL SEGREGATION

What should be done in order to correct coal segregation? Bunker segregation in general can be eliminated to a certain degree by multiple points of loading. In the case of a flight conveyer, as shown in Fig. 5, a trough should be provided with outlet gates. These gates should be opened and closed in such a manner that the bunker will be loaded in horizontal layers instead of from one end. In the case of a silo with center feed, as shown in Fig. 6, a concrete silo, as shown in Fig. 7, or in some similar coal-bunker installation, it is often possible to reduce the amount of bunker segregation by the employment of chutes within the silo or bunker similar to those employed at the University of Illinois.[1] This method consists of providing chutes which carry the coal to several points in the bunker and thereby reduce the amount of bunker segregation by division. These chutes are built with open tops so that, when the bunker is nearly full, the chutes are flooded. Hence the bunker capacity is not reduced.

FIG. 17 PLAN VIEW OF TURNED DOWNSPOUT TO MAKE CORRECTION FOR DOWNSPOUT OR SILO SEGREGATION

Also, in some cases of silo segregation, it is possible to move the elevator 90 deg in plan and thereby change the segregation pattern to one that will do little harm to the fire. Segregation in downspouts can be eliminated by turning the discharge of the downspout toward or away from the boiler. Such an ar-

[1] "Segregation in the Handling of Coal," by D. R. Mitchell, The American Institute of Mining and Metallurgical Engineers, Technical Publication No. 846, 1937.

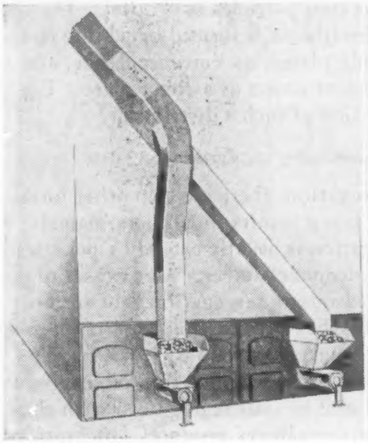


FIG. 18 DOWNSPOUT DIVISION ARRANGEMENT TO OFFSET LATERAL DOWN SPOUT SEGREGATION

FIG. 19 HAND-SWUNG SPOUT

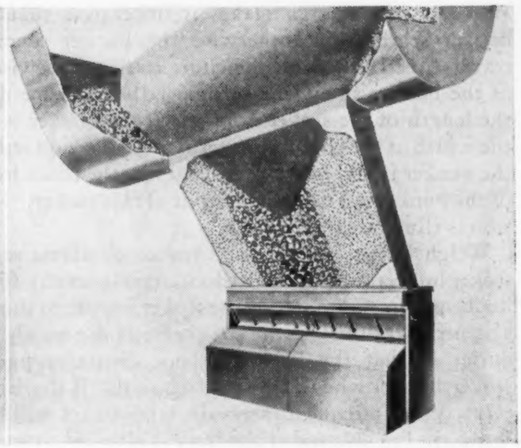


FIG. 20 SEGREGATION IN CONSTANT-WIDTH CHUTE WITH LOW BUNKER

rangement is illustrated in Fig. 17, which shows a plan view of a downspout which connects a coal silo with a conical distributor.

In order to eliminate coal segregation in downspouts feeding two or more stokers, as shown in Fig. 9, a vertical division of the coal flow should be made, as shown in Fig. 18. The elimination of segregation caused by coal scales can be accomplished by so arranging the scale that the feed belt flows toward or away from the boiler.

There are numerous means of eliminating segregation caused by chutes or distributors which put the coal into the stoker hopper. Some plants reduce the air flow under those portions of the stoker that receive the coarse coal. In other words, air segregation is caused to offset coal segregation. Such a procedure is far from satisfactory because changes in the size and type of coal require a change in the air dampers. Even with a mixture that remains the same from hour to hour, it is impossible to adjust the air dampers exactly. This method also reduces the maximum steaming capacity of the stoker.

Many plants have employed the hand-swung spout, as illustrated in Fig. 19. This arrangement consists of a single, pipe-like spout with a hinged upper portion. A handle is provided so that the operators can swing the downspout from side to side. The angle of the swing should be maintained at the minimum, otherwise there is considerable force required to swing the spout over the full width of the stoker hopper. For this reason, the employment of hand-swung spouts is usually limited to small installations. For best results the spout should be swung frequently and a coal valve at the spout outlet should be closed after the spout has been swung. It is possible to install a plate across the center of the stoker hopper to stop the flow of coal when the spout is in the vertical position. Such a plate is the equivalent of an automatic coal valve. Its employment will assist the operator in getting better results.

Mechanically operated swinging spouts are available. These give satisfactory results from the segregation point of view if the spouts are swung the full width of the stoker hopper, and if the speed of the spout is reasonably rapid.

Baffles have been installed within the flat fan-shaped chutes in an attempt to eliminate the segregation caused within these chutes. Designs of baffles have taken numerous forms. In some cases they help a little; usually they impede the flow of coal to such an extent that they prove to be unsatisfactory. In no case, however, can baffles installed in a flat chute be considered as giving more than partial results. Therefore, they are not to be considered as nonsegregating chutes.

In some plants a chute the full width of the stoker hopper is run up to the bunker. Since there is no change in cross-sectional area, such a chute will not cause segregation within itself.

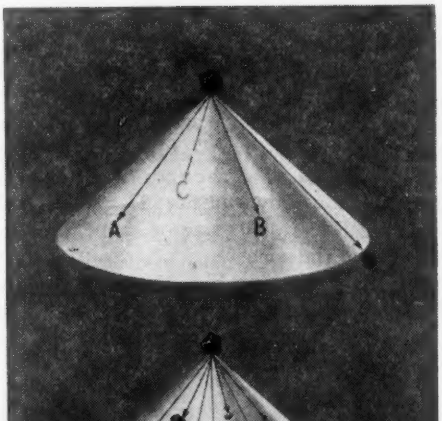


FIG. 21 (TOP) COAL SLIDES DOWN ANY ELEMENT OF A CONE. FIG. 22 (TOP CENTER) COAL DISTRIBUTED AROUND CONE REGARDLESS OF SIZE OF COAL. FIG. 23 (BOTTOM CENTER) SECTOR OF A CONE WORKS SAME AS COMPLETE CONE. FIG. 24 (BOTTOM) LOWER EDGE OF CONE REMOVED IN ORDER TO MAKE CONICAL DISTRIBUTOR

However, this design makes it imperative that there be no bunker segregation, otherwise the bunker segregation will travel directly through the chute itself. Likewise the length of the bunker should be substantially the same dimension as the length of the stoker hopper. If the bunker is longer than the width of the chute, then serious segregation will exist when the bunker is low because the coal fills the chute from the parts of the bunker not directly in front of this stoker. Such a condition is illustrated in Fig. 20.

Weigh larries can be employed to eliminate segregation in stoker hoppers. In order to do so, it is necessary to move them frequently from one side of the stoker hopper to the other. It is also necessary to close the coal valve at the weigh-larry hopper outlet so that the larry does not discharge freely into the stoker hopper when it is standing still. If the larry is moved sideways at infrequent intervals, segregation will be caused, as shown in Fig. 12, and if the larry is allowed to stand with free discharge of coal, the segregation will be caused in the stoker hopper, as shown in Fig. 3.

Good results or poor results will be obtained with the larry, depending upon whether or not the operators put sufficient effort into their job to get a reasonably nonsegregated fuel feed to their stokers.

The conical design of distributor has proved to be satisfactory in eliminating chute segregation. The operation of this type of chute or distributor may be explained as follows: If a lump of coal were placed at the apex of a cone, the axis of which is vertical, and then released, it would slide down any element of the cone, such as *A*, *B*, *C*, or *D*, Fig. 21. Now if a number of pieces of coal were placed at the apex of the same cone and released, the condition shown in Fig. 22 would result, wherein all the coal, regardless of its size or shape, would be equally distributed around the cone.

A segment of a cone, as in Fig. 23, would produce the same result. In order to deposit the coal along a straight line, the conical segment is cut by a vertical plate, as in Fig. 24. The coarse and fine coal remain uniformly mixed in this vertical drop, since the flow of the coal particles is parallel. The conical nonsegregating coal distributor is formed by adding to such a conical segment two side plates, an entrance flange, and another similar conical segment to act as a cover plate. Fig. 25 shows the typical installation of such a distributor.

AIR AND MOISTURE SEGREGATION

In addition to coal segregation, there are two other forms of segregation which affect firing results on stokers, namely, air and moisture. Air segregation is usually caused by poor design of the air ducts or of the plenum chamber. Many cases of poor fires on stokers are blamed on air segregation, but in most of these cases careful analysis has proved that coal or moisture segregation were the real sources of trouble.

On chain-grate stokers, moisture segregation often produces a fire similar to that produced by coal segregation with the exception that coal segregation always produces a definite pattern, whereas moisture segregation usually produces a variable pattern. Most cases of moisture segregation are the result of irregular tempering of the coal by steam in the stoker hopper. From our observations, it is recommended that, if coal is to be tempered by steam, it should be done in the downspout ahead of the distributor, or the coal should be tempered by water as it is introduced into the bunker.

The elimination of coal segregation within the boiler plant should be done when the plant is still in the design stage. The illustrations given herein can be used as a gage to indicate where segregation will occur. Well-considered design will insure that the plant, when built, will give proper operating results. It is just as important to check proposed coal-handling equipment from a coal-segregation point of view as it is to check the drawings for dimensional accuracy.

In an existing plant coal segregation may be eliminated either by proper operation of equipment as installed, or by revising that equipment to accomplish the desired results. Improvement in combustion efficiency, reduction of maintenance, and increase in boiler capacity will result from so doing.

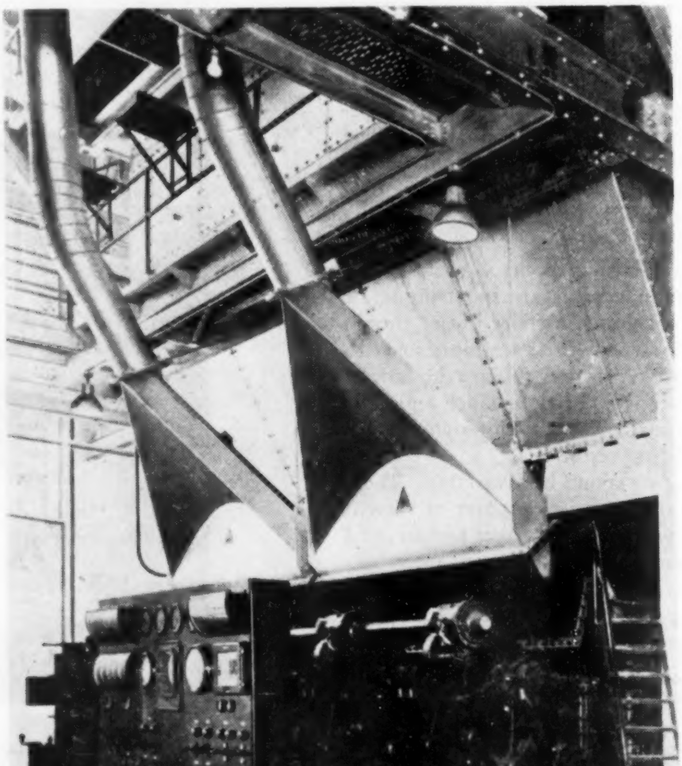


FIG. 25 TYPICAL INSTALLATION OF CONICAL DISTRIBUTOR

The A, B, C of

QUALITY CONTROL

BY J. M. JURAN

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MANUFACTURE begins with a specification of the product to be made. This specification is a piece of industrial legislation, drafted by the design engineers, who are the legislators of the industrial world. The making of products to conform to this legislation is the joint responsibility of the manufacturing engineers and factory personnel who collectively constitute the executive branch of the industrial world. The inspectors perform the judicial function of the industrial world. They compare the product with the specifications to see whether there is conformance. The cycle is completed when the inspection data are used by the design engineers for design modification.

While these three functions of specification, operation, and inspection are clearly separable, they must be co-ordinated if the conformance of product with specification is to be achieved at minimum cost. Conformance of product with specification can be achieved even when functional lines are too tightly drawn. However, overfunctionalization increases the cost of securing conformance. Only through co-ordination of these three functions can minimum cost of conformance be achieved.

THE INSPECTION ACT AND THE PURPOSES OF INSPECTION

The management tool which we have come to know as "quality control" can make an important contribution toward achieving this co-ordination between specification, operation, and inspection. But what do we mean by inspection? Actually there are four different purposes which can be served by what we call "inspection." Yet the steps followed by the inspector "at the bench" are basically unvarying, no matter what the purpose of the inspection he performs. In all cases, the inspector functions as follows: (*a*) Interprets the specification; (*b*) measures the product; (*c*) compares the product with the specification; (*d*) judges conformance; (*e*) disposes of the product; (*f*) records the resultant data. This series of steps we shall call the "inspection act."

While the inspection act is fundamental to all inspection, the purposes served by inspection can be classified into four basic groups:

Acceptance Sampling. This is an inspection on a sampling basis to distinguish acceptable lots of product from nonacceptable lots. Acceptance sampling has for its primary purpose the grading of lots of product. The data obtained are incidental, but can often be put to effective use.

Control Sampling. This is an inspection on a sampling basis, for the purpose of securing data for exercising control. Sampling to regulate the manufacturing process, to rate quality of product, to rate quality performance of operators, or to measure accuracy of inspectors are all instances of control sampling. Here the purpose of the inspection act is to obtain data which can form the basis of management control. Any grading or sorting of product is incidental.

Operational Sorting. This is a manufacturing operation which has the outward appearance of a detail inspection. The purpose is to sort good pieces from bad. The necessity for the sorting arises from the fact that the manufacturing process delivers defective pieces to an extent too great to permit acceptance on a sampling basis. The question of good or poor performance on the part of the operators is not present. For example, the final performance test of a transformer or a generator is an operational sorting. The various operators cannot know whether their collective efforts have resulted in a finished product which meets the tests.

Corrective Sorting. This is also a sorting of the product but arises from the fact that through failure on the part of the operators the product contains defects to an extent too great for acceptance on a sampling basis. For example, a detail inspection for adjustment is necessary only if the operators fail to adjust properly. In such cases the operators are equipped with a full complement of gages, and so forth. They must themselves test to see whether the product is adjusted, for without such test they do not know when to stop adjusting.

Corrective sorting is, for the most part, a "needless" loss. In many shops it is confused with operational sorting and permitted to go on year after year. Furthermore, existence of such sorting is a symptom of an even greater loss—the loss of material plus the time to make good the defectives.

HOMOGENEITY THROUGH MIXTURE AND THROUGH COMMON ORIGIN

In mass production the product can be considered as a stream emerging from the creating source. This stream may be a true stream of liquid or gas, or it may be a continuous solid like an extrusion, or it may be a series of discrete pieces. No matter which of these forms the product takes, there are impinging upon each element of the product, at the time of its creation, the numerous variables in the process. The final characteristics of the product are the result of the combined effect of these variables.

In many cases there is close relation between inspection of product in fluid or continuous form and inspection of product in discrete pieces. For example, measurement of a coil of cold-heading wire for diameter presents much the same problem as the subsequent measurement, for diameter, of the screw blanks cut from that coil of wire. The measurement, for thickness, of a load of spring-steel sheets is a problem much like that of measurement, for thickness, of the steel springs punched from those sheets. The coil of wire and the sheet of steel are each, in a sense, a great many pieces all connected together, and requiring an operation to disjoint them into discrete pieces.

It is valid, even when the product is a continuous or disjointed solid, to consider all product as consisting of a stream flowing from the creating origin. The validity of this concept is in the existence of a reservoir or process which can pour out product. The reservoir pouring out the product may contain much of the product during the pouring process, as in the case of a tank car of gasoline, or the reservoir may be empty, but

[1] Derived from "Control Sampling," chapter 6 of "Management of Inspection and Quality Control," by J. M. Juran, to be published by Harper & Bros., New York, N. Y., in the fall of 1944. For other chapters from this book see "Management Problems of Measurement in the Inspection Function," *Advanced Management*, July-Sept., 1943, pp. 86–91, 103; and "Management Problems in Judging Quality Conformance in the Inspection Function," MECHANICAL ENGINEERING, vol. 65, 1943, pp. 805–808.

Contributed by the Management Division and presented at the Semi-Annual Meeting, Pittsburgh, Pa., June 19–22, 1944, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

making the product as it pours—the miraculous pitcher of today.

The usefulness of this concept of a stream of product lies in the associated concept of homogeneity. Where a mass of product is homogeneous, measurement of a sample can accurately reflect the contents of the mass. A simple instance is present in a homogeneous mass such as a tank car of alcohol. Here physical mixture helps to insure that the sample accurately describes the reservoir. Many other liquids and gases present such uniformity through fluidity. There are also instances of solids such as powder for plastics and glue, for which the manufacturing process includes a mixing to a state of homogeneity. Here also a sample will accurately describe the reservoir.

However, it is important to realize that the stream of solid product pouring from a creating source will likewise reflect the nature of that source, and this will be so whether the source is a full reservoir, or an empty but creating reservoir. There is thus a second form of homogeneity through common manufacturing origin, or through common chain of causation. Any added uniformity through mixture need not obscure the presence of uniformity derived through common origin.

Where the homogeneity is derived from common origin rather than from mixture, measurement of a sample of product can still reflect accurately the nature of the creating reservoir. *The inspected pieces, reflecting the nature of the process which produced them, will also reflect the nature of the uninspected pieces produced by the same process.* This principle is the root of acceptance sampling.

Furthermore, *the inspected pieces will also reflect the nature of the unmanufactured pieces.* This principle is the root of control sampling.

The uninspected pieces and the unmanufactured pieces are thus judged not on the basis that their neighbors are good (or bad), but rather on the basis that the process which produced the inspected pieces, and which did not change, produced (or will produce) the residue.

DEFECT PREVENTION

In measuring the product, the inspector necessarily obtains considerable data concerning that product. Traditionally these data have been given only limited usage in comparison to their potential usage. To a large extent this waste of inspection data still prevails. Even today there are many shops which consider the inspection department to be primarily a mechanism to sort good product from defective, and to reject the defectives. However, the last two decades have witnessed an accelerated development of means to make use of inspection data, that valuable by-product of the inspection act. In a growing number of instances this by-product has become the real objective of the inspection act. In my judgment, this development of use of inspection data is destined to assume the stature of a major contribution of the scientific-management movement.

The most important use to which inspection data can be put is to prevent defects from being made in the first place. This is clearly a sound objective. If less defects are made in the first place, there will be less inspection, less rejection, less repairs, less junk, and less defects to go to the consumer. In the extreme case, where no defects are present, the quality problem reduces to one of preserving the status quo.

Use of inspection data to prevent defects from being made in the first place necessitates:

1 Determining, from the inspection data, the extent and kind of defects present in the product.

2 Investigating, to find and correct the conditions which cause the defectives to be produced in the first place.

3 Keeping the frequency of defects to a practical minimum, once such minimum has been attained.

Steps (1) and (2) are quite common in industry. Occasionally a process may begin to turn out 100 per cent defective work, whereupon the management must call a halt until an investigation finds and corrects the causes. Step (3) is by no means rare but is carried on largely by rule-of-thumb technique. Yet the extensive usage of these three steps, fortified by modern scientific techniques, can be almost revolutionary in giving the shop management a real grip on the problem of securing economic conformance of the product with the specification.

The foregoing discussion has been worded in unscientific language as a means of explaining the practical significance of this "defect prevention process." If the reader has closely followed the explanation of the defect-prevention process, he is hereby informed that he has acquired an understanding of the basic principles of control charts and statistical control, and that there now remain merely a few details to make this understanding complete for practical purposes. Before going on to these details, it remains only to emphasize one more important principle: *There are times when it is desirable to investigate a process even when it is producing no defects at all.* The fire department once operated on the basis of waiting for a fire to break out and then quenching it as quickly as possible. Modern fire-department practice includes fire prevention—a continuing search for things which cause fires, and elimination of these causes before they burst into flames. This same prevention principle is the very heart of the defect-prevention process.

STATE OF CONTROL AND ASSIGNABLE CAUSES OF VARIATION

In making practical application of the defect-prevention process, various questions of precise definition arise. Suppose that, in the manufacture of lamps, the percentage of lamps below brilliance standards is 23 per cent, yet upon investigation no one thing seems to be the cause. What then? Again, suppose that the percentage of dim lamps is only 2 per cent. Is it worth while to conduct an investigation in the hope that the cause of these dim lamps can be found? Suppose there are no defects. May it be worth while to conduct some sort of investigation? These are practical and perplexing questions. Yet there is a way to answer them from the inspection data. There is a means of judging, *from the inspection data alone*, whether a process is doing its best. In other words, the inspection data can tell whether 23 per cent of dim lamps is inherent in the process, or whether there is present in the process some foreign element never contemplated by the process engineer. The test data can also tell whether some foreign element is present even when the process is turning out product which conforms perfectly to the specification limits.

That such seemingly mysterious determination can be made arises from the fact that *the fewer foreign elements a process contains, the greater will be the uniformity of the resultant product.* By "foreign elements" we mean here some tangible cause such as poor workmanship, defective component parts, inaccurate test devices, etc., which can be traced down as a specific cause yielding a specific influence. We shall refer to such foreign elements as "assignable causes of variation." In the extreme case of a process which contains no assignable causes of variation (we shall refer to this as a "state of control"), the degree of uniformity for that process has reached its limit. (The process will, however, never produce pieces which are absolutely identical.)

But how are we to know that this limit of uniformity has been reached? Must we continue blindly to study and restudy the process looking for more and more assignable causes of variation? Not at all. There is a statistical test which we can apply to the inspection data. If upon applying this test the answer is "lack of control" then the process still contains assignable causes of variation, and we may wish to investigate further. But once the statistical test gives no indication of lack of control, the search for assignable causes of variation is at an end.

The foregoing principles, restated in this nontechnical terminology are that:

1 A process containing assignable causes of variation yields a product which is less uniform than a process which contains no assignable causes of variation.

2 A process containing no assignable causes of variation has attained maximum uniformity and is said to have reached a state of control.

3 We can determine by a statistical test whether a process has attained a state of control (and therefore whether it contains no more assignable causes of variation).[2]

This statistical test is a management tool of great versatility. Not only can it tell when a process has attained a state of control; it can also tell when a process departs from a previously existing state of control. It is thus a "gage" for the process for it states whether the process is or is not doing the best quality job it can do. Such a gage is obviously of great value, and it must be clear that use of this gage will become widespread. Indeed, the use of this statistical test has made great strides in the last decade or two.

VARIATIONS IN MANUFACTURED PRODUCT

To understand what is a state of control and what is an assignable cause of variation requires a consideration of the nature of variations in manufactured product. That no two pieces of manufactured product are precisely alike is axiomatic. Johansson or Hoke gage blocks made to 1 in. thickness are all unlike in thickness even though the differences may appear beyond the seventh or eighth decimal place. Successive pieces produced by a manufacturing process also differ one from another, and the differences are due to a multitude of causes.

Consider an operation of winding small electrical coils. The operator has a supply of small empty spools and a large reel of supply wire, a power-driven chuck, scissors, sandpaper, a soldering iron, and other such tools. The specification limits for ohmic resistance are in this case: min 33.0 ohms, max 36.0 ohms. The operator is given suitable instructions and soon a batch of fifty coils is ready for test.

We test five coils and obtain the following results in ohms: 33.7; 32.9; 33.5; 33.2; 33.5.

Why are the results not identical? For many reasons. A knowledge of the process can yield dozens of contributing factors—the wire from the supply reel is not perfectly uniform in resistance, the tension while winding coils is not constant, the length of wire allowed for finishing is not uniform; the resistances of the terminal wires are not uniform; the contact resistance of the test set is not uniform, etc.

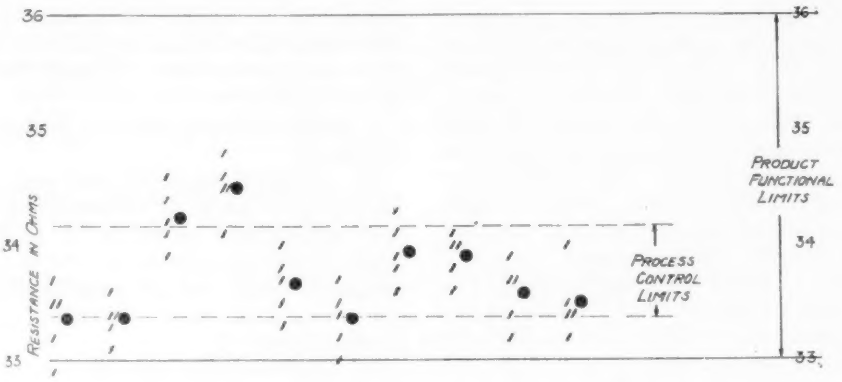

CHART 1

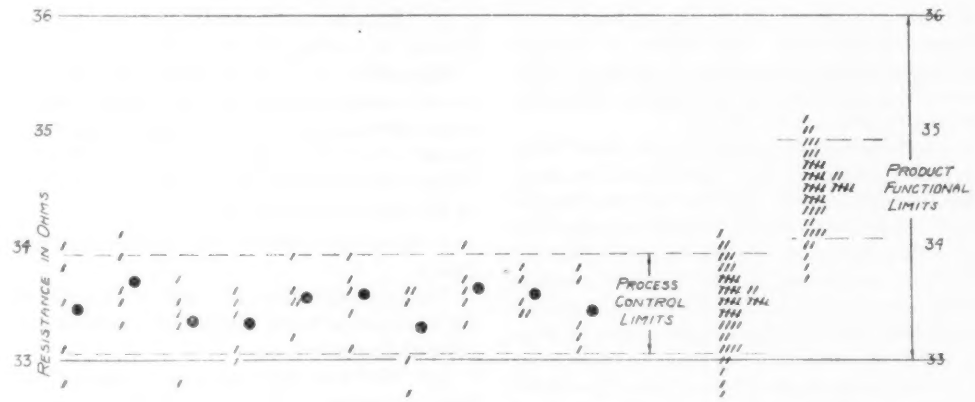

CHART 2

Nine additional batches of fifty coils each are produced and we test five from each batch. This mass of fifty numbers is difficult to interpret by eye. To make interpretation easier we chart the results (Chart 1). Now some things stand out clearly. Batches Nos. 3 and 4 seem to be somewhat higher in resistance than batches Nos. 1 and 2. We seem to be encountering, between batches, some important variable. But do we in fact have such a variable? Frequently we can judge by eye, but in doubtful cases we can apply our statistical gage, and it will resolve the doubt for us.

To apply the statistical gage we must compute "control limits" (not to be confused with specification limits). Control limits are the boundaries of the variation in product quality which can be reasonably expected from a controlled process. If the inspection data remain within the "control limits," the process is performing with maximum uniformity. If any of the inspection data do fall outside of the control limits, then

[2] Theoretically this is not quite correct. The statistical test does not establish the presence of a state of control. It only establishes that there is no evidence of lack of control. Lack of control might be present but might give no evidence of its presence. In practice, this distinction is ignored.

the process is not doing all it should, and this because of the presence of some dominant variable which can be identified by an engineering investigation of the process.

Applied to the case at hand, the control chart consists of plotting the average values of resistance on a chart on which the control limits are drawn. As was surmised, lots Nos. 3 and 4 are outside of limits. Conclusion—the process is not controlled.

FINDING ASSIGNABLE CAUSES OF VARIATION

Why is the process cited out of control? The control charts alone cannot answer this. The answer is to be found in the shop. So into the shop we go.

We find that the shop supervisor had reasoned that to meet specification limits of minimum 33.0, maximum 36.0, he should aim at the mean of 34.5. He secured an electrician's handbook and found that for this size of wire, at mean diameter, 34.5 ohms was the resistance of 10 ft of wire. The diameter of the spools was such that 10 ft of wire would yield 120 turns on a spool. Hence he instructed the operators to wind exactly 120 turns on each spool. We unwind several coils from lots 3 and 4 and find that they do indeed have 120 turns. The trouble is not caused by variation in the number of turns. Then we realize that the 120 turns is valid only for wire of mean diameter. Are the supply reels of wire all at mean diameter?

As we investigate this, we find that the supply reels of wire contain about 1000 ft each, enough for about 100 coils, or two lots of fifty. We measure 10-ft lengths of wire from five different reels, and we find measurements of 34.3, 32.8, 35.3, 34.6, 35.1. This spells trouble, for one of these lengths is already outside of specification limits, and coils wound from it will very likely be outside of limits.

To eliminate this variable, we talk with the engineers of the company which furnishes this wire. They advise us that the wire is commercial and that the alternative would be to select special reels of wire which meet these closer limits. This, they say, would be very burdensome and expensive.

By this time the winding-room supervisor has an idea. Why not cut from each reel a length of wire such that it measures 34.5 ohms and then cut the rest of that reel up into lengths equal to the sample? In this way we can take advantage of the uniformity within reels while avoiding the variation between reels. This is tried out, and a new control chart is prepared (Chart 2). According to this chart, all is well, for the process shows no lack of control. But the shop supervisor is far from satisfied, for three of the 50 coils, or 6 per cent, are defective.

Clearly, the ideal process is one that meets both the control limits and the specification limits. Once again we chart the data, this time as though the coils were sorted in bins according to their electrical resistance (left-hand scatter chart of Chart 2).

The new situation is clear. Whereas we had cut the wires to measure 34.5 ohms, the coils cluster around 33.5 ohms. This average is too close to the minimum limit and allows the lowest-resistance coils to be defective. This is an unhappy situation when we note that there is plenty of leeway near the maximum limit. But what made the resistance go down? Again we go into the shop.

We examine the winding operation itself and the answer is obvious. In soldering the wire to its terminal, the operator scrapes the insulation off the wire several inches from each end. She then holds the wire with one hand while she solders, holding the soldering iron in the other hand. After soldering there remains at each end several inches of wire to be clipped off. The remedy is obvious. We should provide these extra inches in the first place.[3] This the shop supervisor does by cutting the lengths to measure 35.5 ohms at the outset.

This change requires a change in the control chart (right-hand scatter chart of Chart 2).

Now all is indeed well. Control has been achieved, and the product is well centered between the specification limits. It now remains only to maintain control.

Note that there are areas between the control limits and the product limits. As the process gets out of control there will be time to take corrective action before defects are actually produced. This is a most desirable situation.

RELATION OF CONTROL LIMITS TO SPECIFICATION LIMITS

The foregoing example embodies many important elements of the statistical-control problem. In particular the relation of control limits to specification limits should be fully understood. It must be realized at all times that the basic objective of the process is to meet the specification limits and to do so economically. In general, a controlled process is to be preferred over a process out of control. However, there are cases where the effort required to secure control cannot be justified in the light of the specification limits. To study this let us consider several classes of problems:

1 Process not controlled, and product fails to meet specification limits.

The example in which the coils were out of limits because of the reel-to-reel variation illustrates this point. In such cases a shop investigation should by all means be conducted. The object of the investigation should be an identification of the assignable causes and an understanding of the difficulty of eliminating such causes. Economic considerations will then dictate whether to:

(*a*) Eliminate the assignable cause (as was done by going to a measured length instead of using a count of number of turns).

(*b*) Change the specification, e.g., changing the limits to max 35 ohms, min 32 ohms.

(*c*) Endure the condition by sorting the product and repairing or junking the defectives.

Frequently it is found that elimination of the assignable cause is simple enough and the matter can end there. In other cases, elimination of the assignable cause may be very expensive. In such event, the engineers must be called in to decide whether or not the expense is warranted in the light of the importance of the specification limits.

2 Process controlled, yet product fails to meet specification limits.

The example of the coils which were out of limits because of the excess wire being clipped off illustrates this point. In such cases the answer is to:

(*a*) Make a compensating change in the process (as was done by providing more wire at the outset).

(*b*) Change the specification (as by lowering the minimum limit to 32.5 ohms).

(*c*) Endure the condition by sorting the product and repairing or junking the defectives.

Again, the choice of these actions is an economic problem.

3 Process not controlled, yet product meets the specification limits.

If in the problem of the coils the limits had at the outset been max 36 ohms, min 32 ohms, then the product units would all have met the specification limits despite the lack of control. Under these conditions, would we have been justified in making any investigation at all? Indeed we would. Lack of control means that some important variable is rampant. We should at least know the nature of that variable to judge to what extent it can affect the product. The same variable, for all we know, may shortly grow to an extent sufficient to put the product outside of specification limits.

Whether to go to the effort of eliminating the variable once it has been identified is quite another problem. If the coils all met the wider specification limits, would we have been warranted in going nonetheless to the more expensive procedure of cutting equal lengths of wire from a reel to take out the reel-to-reel variation? Possibly not. One cannot make it an in-

[3] Another solution is to solder the wire much closer to the end.

flexible rule that if the specification limits are met one can forget control, any more than one can make it an inflexible rule that no matter how readily the product meets the specification limits, investigation must continue until control is attained. A proper answer involves a consideration of the numerous supplemental advantages of a state of control.[4]

4 The process is controlled and the product meets the specification limits. The final result of the coil problem exemplifies this.

In general this situation calls for letting well enough alone. However, where the variations in product are quite small when compared to the specification tolerance, and where the process contains expensive operations to keep product variations small, it may be that some of these expensive operations can be dispensed with while still providing margin between the new control limits and the product limits.

When the product is controlled and the control limits are well within the specification limits, the control chart has an additional and almost startling use, for it can disclose any gradual tendency for the product to approach the specification limits before such tendency has produced defective pieces. We noted this in the coil example. *The importance of this feature cannot be overemphasized.* Not only is this feature an advance storm warning, it usually allows time to go into the shop for shutting off the storm.

Finally, we must note that in general (but not always) the specification limits apply piece by piece, whereas the control limits apply to the process as a whole. There is an enormous and relatively unexplored field open to design engineers for development of functional limits which are keyed to the control limits of the manufacturing processes. This unexplored field involves a new philosophy of manufacture which offers great promise for still further improvement in quality control.

THE NATURE OF ASSIGNABLE CAUSES OF VARIATION

Instead of using the word "assignable," we might well have used the term "dominant" causes of variation, for the practical distinction between an assignable and a nonassignable cause is also one of order of magnitude. If the variation from reel to reel in the coil problem had been very small instead of quite significant, then the coil-winding process would have shown control in the first place. On the other hand, if the operators had allowed widely different lengths of wire to become "excess" during the soldering operation, then *that* variable might have appeared in size sufficient to throw the process out of control, and would have been classed as an "assignable" cause of variation.

Thus while the term "assignable" conforms with standard usage, it should be realized that in practice it means "big enough to make itself noticeable." If a cause of variation towers in size well above the other causes of variation, it earns the notoriety of "assignable." Otherwise it is merely one of the legion of variables which are present in any process, and which are ignored because they are sufficiently well behaved. True, elimination of *any* variable improves in some degree the uniformity of the process. However, only elimination of "assignable" causes of variation can make any significant change in uniformity.

If this coil-winding job were to be studied with a view of meeting very much closer specification limits, such as min 34.0 ohms, max 34.5 ohms, then it would be necessary to:

(*a*) Study closely the variables heretofore considered nonassignable, to reduce the effect of each on the process (the result of all these changes might virtually be a new process).

(*b*) Or, add a new operation to the process, such as calibration of resistance during the soldering operation.

There is thus no clean-cut separation between assignable and nonassignable causes of variation. In practical operation, the difference is signified by whether the variation in question shows the process out of control as evidenced by the control chart. Thus the attainment of control is in a sense the identification of the dominant variables and the shrinking down of the effect of such variables to a level such that the variable no longer has a dominant effect. There will remain a seething mass of lesser variables, none of which is dominant, and all of which are associated with one another in bewildering combinations. These combinations minimize the chance of the variables all tending in one direction, and thus yield randomness.

RETAINING AN ESTABLISHED STATE OF CONTROL

The attainment of a state of control should preferably be part of the original manufacturing planning of the job. But, whether undertaken at the outset or at some later stage of the job, the attainment of control introduces the problem of how to retain the status quo. The key to this problem is the control chart itself.

The control chart lends itself admirably to swift review by the shop supervisor and the executive alike. This is so much the case that a family of control charts, depicting the quality performance of an entire shop, can be reviewed by an executive in a matter of minutes. This is a most desirable state of affairs for executive control.

Use of the control chart to retain control requires that:

1 The inspector record the prescribed data.

2 The results computed from those data be plotted on the control chart daily (or hourly, weekly, etc., as circumstances dictate).

3 The control chart be reviewed by the responsible supervisors.

4 Instances falling outside of the control limits be subjected to a shop investigation for correction.

None of this merely continues to happen. There are many things competing for the attention of the shop people, and there is the constant urge to defer keeping the charts up to date in order to take care of some pressing matter. But up-to-date information is vital to maintaining control. Keeping up to date can be accomplished only by giving to the control charts a high enough priority.

In like manner, investigation of instances falling outside of the control limits is by no means automatic. A human being does not rush to his physician at every unusual ache or pain; he hopes the matter is transient and that the symptom will shortly disappear. He may be reluctant even to learn the worst. The shop supervisor is human and has a similar view with respect to the process whose symptom chart shows points outside the control limits. Life would be simplified greatly if this condition cleared itself up, and the supervisor is not disposed to deny the process such an opportunity.

This thinking is not altogether devoid of logic. However, it is unwise to delegate the right to ignore danger signals. The executive who reviews the control charts should insist on explanations for all instances which are out of control unless he himself has given a waiver. And he should not give many waivers.

INVESTIGATING LACK OF CONTROL

In practice, the first step in investigation of lack of control is a recheck of the test equipment, gages, inspection standards, etc., to see whether they are calling normal product "abnormal;" viz., one questions the measurement rather than the product. This is logically the first step. Furthermore, the man who first knows about the failure to meet control limits (the inspection supervisor in this case) learns from experience the wisdom of avoiding false alarms.

If this recheck proves the product has indeed changed, the operating shop or the process engineer is brought into the

[4] See "Guide for Quality Control and Control Chart Method of Analyzing Data," American Standards Association, Standard Z1.1–1941 and Z1.2–1941.

picture. Here, a technical knowledge of the inspection item involved helps in locating the source of trouble. Obviously, only those conditions which can influence that inspection item need be examined. However, sometimes a totally unexpected influence has crept in. The shop supervisors associated with the job are a valuable source of information. Day after day these supervisors handle the materials and operate the machines. They know, for example, that there was a power shutdown for 15 minutes. They know, for example, that an experimental batch of pieces being tried out by an engineer became lost and probably became mixed with regular product. They know much other shop lore which seldom appears on control charts. No experienced investigator will ignore such sources of information.

Not infrequently the cause for the change in process is a multiple cause. Several factors contribute to a composite result which is unsatisfactory. Each contributing organization points to the others, and the technical problem is dwarfed by the problem in human relations. These responsible for correcting the condition must display high qualities of leadership and tact to correct such situations.

REVISION OF SPECIFICATIONS AND PROCESSES

It has been noted that attainment of a controlled process is only part of the problem of defect prevention. In addition, the control limits of the process must bear a sound relationship to the limits of the product specification. The implications of this are far-reaching, for the development of this "sound relationship" means, in essence, use of inspection data to revise processes and specifications. This completes the chain of information from specification, to manufacturing planning, to manufacture, to inspection, and back to specification.

It must be obvious that, when the process has reached a state of control, the shopman has reached the limit of what he alone can do. Given a controlled process which nevertheless produces defects, only an engineer can provide the remedy. Either the process engineer must make an adjustment in the process, or the design engineer must make an adjustment in the design limits.

Ideally, the control limits for the process should be comfortably contained within the product limits; there should be a margin of safety. Such margin provides that valuable no-man's land within which the process may go somewhat out of control but without producing defectives. In this way action to get the process back into control may be taken before defectives are produced.

Where no such margin of safety exists, the facts should be brought to the attention of the interested organizations. Sometimes provision of such a margin is ridiculously simple (as in the case of the coils discussed earlier). This is usually true when the distance between control limits is substantially less than the distance between product limits. The problem in such instances reduces to one of "centering" the process within the product limits. Such "centering" is normally accomplished with ease. A process engineer usually faces no trouble in making the product on the average thicker, longer, shorter, harder, etc. It is these types of changes which accomplish "centering."

However, where the distance between control limits approaches the distance between product limits, even a controlled process will regularly produce defects. This may, of course, be aggravated if there is lack of "centering," and, frequently, the percentage of defectives can be reduced by achieving "centering." But beyond this the answer lies in:

1 Enduring the resultant percentage defective.
2 Revising the process so that it yields greater uniformity of product.
3 Widening the product limits.

The decision in any one case is obviously a decision on the special facts of that case. Consideration must be given to the difficulty of securing greater uniformity in the process, to the importance of the product limits, to the ease of sorting the product for defects, to the expense of repairing or junking the defectives, etc. But in all cases the decision can be more accurate if the inspection data have been cast into that form which most clearly portrays the facts.

Unless the program of "quality control" recognizes the possibilities inherent in use of inspection data to revise processes and specifications, one of the most important benefits of modern quality-control technique has been disregarded. Such disregard has its repercussions on the remainder of the program as well. The inspection supervisor who knows that a controlled process regularly produces defects anyway soon learns that as the process gets out of control the percentage of defectives rises. He may then prefer to take action from the per cent defective data rather than from the control chart, for he can more readily explain the former to the operating supervisor. This reliance on percentage defective may also extend to those cases in which the control chart is a far better mechanism for regulating the process. The result is a serious limitation on the usefulness of the control charts.

POINT OF DIMINISHING RETURNS FOR USE OF CONTROL CHARTS

If the principle of control charts were carried out to the bitter end, there would be a control chart for every inspection item for every variety of piece or assembly made. In a large shop this would run into literally millions of control charts and would be manifestly absurd. Clearly, there are varying degrees of need for control charts, and there are circumstances under which the effort required to set up and maintain the control chart is not economic, e.g., in jobbing work or in other varieties of nonrepetitive manufacture. The control chart is a comparison of the present with the past, and is of no avail where there is no past, or where the past is so remote as to be useless for purposes of current prediction.

THE PLANT EXECUTIVE AND THE CONTROL CHART

The alert plant executive ever strives to obtain firsthand knowledge of shop activities. Such firsthand assurance can greatly increase his grasp of the situation and can enable him to judge the extent of color present in the reports his subordinates bring him. However, much as he would like to see a great deal at firsthand, the limitations of time are against him.

The control chart provides a means whereby the quality features of shop processes can be paraded before the executive for his review. The control chart is a factual report, and there is no interpretation to be applied by a subordinate. The thing speaks for itself. Again, the control chart is so brief and clear that dozens of them can be reviewed in a short time. Those which show no lack of control can be passed over. Attention can be concentrated on those which show lack of control.

This feature of directing supervisory attention into those channels which require attention is of great practical value. The effort of shop executives is spread over too much territory to permit full vigilance in all areas. It is therefore of great importance that the determination of what areas are to receive attention be based upon data rather than upon guess. The control chart can go far in directing supervisory attention into the proper channels.

TECHNICAL PROBLEMS OF THE CONTROL CHART

I have in this paper deliberately refrained from any discussion of the strictly technical problems surrounding the construction of control charts. Those who need to know the A, B, C of quality control are for the most part not concerned with how to construct control charts. They are concerned with knowing "what good is it and how do you operate it." But if a plant is to use these statistical tools, it will need a statistical toolmaker, who thoroughly understands these technical problems. How-

ever, he need not be a mathematical statistician. The mathematical basis for the computation of control limits is by now largely reduced to tables which can be used effectively by any engineer. The shop executive, unless he has a penchant for mathematics, will do well to avoid the field of mathematical statistics and confine himself to a practical understanding of "what good is it and how do you operate it?"

For the engineer who is to use these tables, there is available a well-developed literature.[5] The younger engineer will do well to avail himself of this, for it is he who will be called upon to supply the technical skill for applying these control charts. He will be well rewarded for his diligence, for he can become a pioneer in this new technology which even today presages an engineering romance.

In the last decade, the mathematical techniques have been developed at a pace greatly exceeding the rate of practical application. Statisticians are today developing further refinements, and doing so in some areas which have received only limited test in practical application. This great body of technical development is often bewildering to a plant executive who may conclude it is hopeless to teach shop supervisors anything so complex.

The plant which is beginning the application of the techniques need not, and should not, at the outset be concerned with these refinements. It should concentrate on the application of the simple techniques. A plant which is undertaking product inspection for the first time has for the moment a sufficient task without trying simultaneously to solve the problem of gage inspection. The first application of simple control charts may derive 80 or 90 per cent of the possible benefit, whereas an effort to include complex statistical refinements may so increase the difficulty of making the applications that the entire project may become discredited or even fail altogether.

SUMMARY

Modern quality-control technique is directed primarily at preventing defects from being made rather than primarily at sorting the product after defects have been made. Defect prevention requires that the manufacturing process be examined for any assignable causes of variation which are not inherent in the process. The detection of such assignable causes can be accomplished by analysis of the inspection data. The elimination of the assignable causes requires a shop investigation and associated corrective action.

The statistical technique serves many purposes during this procedure. At the outset it indicates the presence of assignable causes of variation. Subsequently, when the process reaches a state of control, the statistical technique provides assurance of the absence of assignable causes of variation. In the final stages the statistical technique maintains a vigilance over the controlled process and announces the entry of any new assignable causes of variation.

The control limits of the statistical technique must be established with full knowledge of their relation to the functional limits of the product. A controlled process is not an end in itself; it is a means to the end of meeting the functional limits in the most economical manner. Accordingly, the relation of the control limits to the functional limits should be adjusted to accomplish this economic objective.

The control-chart technique is admirably suited to facilitate executive review. This executive review carries with it the responsibility to see to it that corrective action is taken where such action is indicated. In the absence of corrective action, the control-chart technique deteriorates into a sterile paperwork procedure.

The technical problems of constructing control limits and control charts have been fully treated in the extant literature. The hypotheses and formulas have been reduced to practical tables which can be applied by the average engineer or shop supervisor.

When a controlled process produces defectives, or can with little disturbance produce defectives, consideration should be given to revising the process or the specification to provide suitable margin between the control limits and the specification limits. Given a proper margin, the control chart discloses the presence of assignable causes of variation before such causes produce defects. This timely warning permits correction of the condition before any defectives are produced.

The use of inspection data for revision of processes and specifications is a long step toward achievement of full cooperation between the engineers and the shop, and toward unifying the entire shop in the handling of the inspection function.

[5] A good beginning is the American Standards Association publication, supra.

Postwar Problems

(*Continued from page 504*)

invest money because of lack of confidence in what the future may hold, and if unemployment continues to be severe, the increased money supply can be sterilized by reluctance to spend. Higher prices are an almost inevitable parallel of postwar prosperity; stable or lower prices can only be expected, in the early postwar years, at least, in conjunction with depressed business activity. The argument that a great expansion of the circulating medium, such as we have had since 1940, can be followed by a great boom in physical volume without an increase in prices, flies in the face of history."

The analysis by this committee leads to the opinion that both the volume of business and the general price level will be higher following the war than they were before 1940. This follows the precedent of the first world war; prices rose from 25 to 30 per cent in one year from 1919 to 1920, and averaged over the entire 1921–1929 period, more than 40 per cent higher than the prewar level. The monetary pressure behind prices is greater today than it was during 1917–1920. More conservative economic and political thinking over the next few years is likely to increase business, financial, and consumer confidence and lead to freer spending, active business, and higher prices. Price controls, after the war, are unlikely to do more than slow down price increases that are justified by higher costs and market demand. No wild upsurge in prices is expected, but we can reasonably expect a general postwar price level one third to one half above that of 1940. It is already one fourth higher.

We are told that there will be a new and better world when the war is over—the sacrifices of war will wash the past away. We wish to believe this; it appeals to our sense of justice and compensation in that the sacrifices of our soldiers and their families deserve a better world—"a world fit for heroes to live in," as England hoped for after the first world war.

But war solves no peacetime problems; war strides in and rudely thrusts them aside, and generates new problems of its own for peace to solve.

So when this war is over, we must take up where we left off and assume the added burdens that war will leave behind.

I am confident that we can do this; that we will find tolerable solutions for the problems we will encounter after the war; that we can produce enough to carry the added burdens of debt and destruction; but these hopes will be realized in good measure only if all of us are wise enough to work together for our common good. Industry management cannot do it alone; labor cannot do it alone; Government cannot do it alone; only all of us, working together, can do it.

CUTTING-TOOL PERFORMANCE

Increasing Tool Life and Life of Machine Parts by Combination of Chromium Plating and Aftertreatment by Lundbye Process

By AXEL E. LUNDBYE

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THE history of chromium plating dates back to 1848, when Junat was granted a patent in France for a method of plating chromium. In 1854, Bunsen, famous for the burner that bears his name, made some interesting experiments with this type of electrodepositing.

The author was fortunate in having had the opportunity to do experimental work on chromium plating some 30 years ago. Of course, at that time, and up to a couple of years ago, it was impossible to apply chromium to steel so that it would adhere when pressure, and especially variable pressure, was applied to the chromium; it would spall and peel off.

Chromium plating of cutting tools had been tried many times with varied success in the last decade. In the early 30's, many concerns attempted this type of electrodeposit on cutting tools with the hope of increasing their life. However, in most cases, it was a failure, due to the fact that the chromium would not adhere to the underlying material when the tool was put into use and pressure was applied.

A PRINTING-PRESS PROBLEM

About 3 years ago, a mechanical problem arose in the Springfield, Ohio, plant of the author's company, which was placed in his hands for solution. Eight giant rotogravure presses had just been installed at great expense for a new method of printing color work at a high rate of speed. The printing is accomplished with etched-copper cylinders. One of the members of the equipment required to accomplish completely satisfactory results is a long flexible steel blade, known as a doctor blade.

This doctor blade can be compared to a safety-razor blade with the exception that it is 72 in. long, 4 in. wide, and approximately 0.004 to 0.006 in. thick. These blades wore rapidly, and about every 6 to 8 hr, the presses had to be shut down, so that the blades could be removed and reground. The problem involved was to find a member that would last longer and do a better job.

Nearly every possible solution was tried, including ferrous and nonferrous metals, plastics, rubber, synthetic and otherwise, but without success. Then we tried chromium plating, at the same time realizing that this type of plating would not work without additional treatment. However, certain ideas concerning the problem were applied and found to work satisfactorily.

CHROMIUM-PLATING STEEL WITH AFTERTREATMENT

In the course of research and investigation, we discovered a method of plating chromium onto steel with an aftertreatment, so that the chromium became an integral part of the underlying material. This was a wholly new thing in metallurgy. As stated, prior to this, chromium would peel and scale from the base metal when pressure was applied to the part that had been plated. We produced a number of doctor blades with a chromium plating only a few microinches thick, and after giving them the aftertreatment, we increased the life of these blades from 8 to 110 hr minimum, which provides for a complete issue of any of our magazines. How much longer they will run we do not know, because after 110 hr, we have to take our presses apart and clean them for the next issue. While the presses are down, the blades are reground.

These doctor blades are under great variable unit stresses. In addition, because of the construction of the blade holders, the blades are subjected to a considerable amount of bending. In applying a fairly thick plating of chromium as previously attempted, the chromium would not follow the movement of the base metal, but would peel or spall off.

After we had satisfied ourselves that we could make a chromium plate adhere to doctor blades without danger of peeling when pressure was applied, we proceeded to try this process on cutting tools. As we have quite a large machine shop, it became our proving ground. For the first time in metallurgical practice, we were successful in plating and treating all kinds and types of cutting tools, thereby increasing their life in our shop on the average of 400 per cent, and simultaneously increasing production $33\frac{1}{3}$ per cent.

When first offered to industry, a great deal of skepticism was expressed concerning this process. It must be remembered, as late as 1939, in discussing ordinary industrial or "hard" chromium plating it was stated authoritatively,[1] "the plate is extremely brittle and should not be employed for tools subjected to shock." Further, it was stated, "when in addition they must operate at high temperatures, they are almost worthless."

Nevertheless, the results were immediately reported to Donald Nelson of the War Production Board, who referred the matter to Mr. Harrison, then head of the machine-tool industry in the United States. It was decided that the author's company would offer this process, without royalty for the duration, to any industrial concern in the United States doing war work. We also offered our services with this process as consultant to those interested.

SIMPLIFYING THE CHROMIUM-PLATING INSTALLATION

Before this process could be released to industry in general, it was necessary to simplify the chromium-plating installation. We stripped everything from the standard tanks, and reduced the installation to the greatest possible degree. This was necessary in order that the average operator could be taught to use the process quickly. Success attended our efforts, so that now several hundred manufacturers are using this process in their plants. Most of these had no prior knowledge of chromium plating.

We have plated and treated sample tools for several thousand companies in the United States and Canada, and are still doing this work. Any manufacturer doing war production can send tools to our laboratory for treatment. However, we request that two or three of each type of tool be sent, so that a fair test may be assured. We do not consider it to be a fair test if just one unit of each tool is used. We request further that

Contributed by the Research Committee on Metal Cutting Data and Bibliography and presented at the Spring Meeting, Birmingham, Ala., April 3–5, 1944, of The American Society of Mechanical Engineers.

[1] *Metals Handbook*, 1939, p. 1102.

manufacturers send in tools with which they are having the most difficulty, and usually we get them.

The only thing we ask in return for our efforts is that the companies, supplied with treated tools, write and tell us how they compare with untreated tools of the same kind doing the same work. Should the results prove to be less satisfactory than have been attained by other manufacturers, we will be glad to do additional work for them. In most cases of failure, the reason has been found to be in the shop where the test was conducted.

However, if it is found, as in the case of most companies, that tool life has been increased 2, 3, 4, and up to 50 times, we will be more than glad to help the manufacturer design and install this process in his own plant, furnishing him with blueprints in the rough. Our services as consultant will be at his disposal up to the time the plant can handle this process as well as we do. Companies may also send one or more representatives to our laboratory in Springfield, Ohio, and we will train them in the technique, which takes only a few hours. As previously stated, there are no charges for any of these services. It is one of the contributions to the war effort being made by the author's company.

RESULTS ACHIEVED BY PROCESS

Some very wonderful reports have been received from companies which have used this process. Several manufacturers have reported 50 times the life of unplated tools; which we consider high. We usually state that tool life can be increased 300 per cent.

Figs. 1, 2, and 3 are charts showing results obtained. Data were compiled from reports of 180 companies, 6 different types of tools in sets of 30 each being selected. It was decided not to use any reports that went beyond 3000 per cent increase.

Referring to Fig. 1, the solid line indicates reamers; the average increased life for 30 sets was 466 per cent. The dotted line represents drills, and the average increased life was 406 per cent.

In Fig. 2, the solid line refers to taps and thread chasers, showing an average increase for 30 sets of 577 per cent, while the dotted line represents tool bits and forming tools, 30 sets averaging 391 per cent.

In Fig. 3, the solid line indicates milling cutters with an average life of 415 per cent for 30 sets; and the dotted line is for gear cutters, hobs, broaches, and special cutters, averaging 304 per cent for 30 sets.

Taking into consideration all 180 sets of tools, we find that the average increase in tool life was 426 per cent. This means that the companies using this process extended their present supply of critical tool steel for these tools approximately 4.25 times, but it also means that the toolmakers and grinders went 4.25 times as far. This would not have been so important a few years ago, because at that time, wearing out of tools or machine parts was considered nothing but an inconvenience in the operation of production equipment. Replacements and repairs were only a few of the many functions of production planning. However, that was before tool steel, as well as other vital metals, and the fabrication of them, came under the critical conditions of today.

As skilled craftsmen and materials grew more and more difficult to obtain, the operation and replacement of worn out tools and parts no longer was a minor factor, but a very serious problem in our constant stepping-up of production of weapons and equipment for our war effort.

Before this point was reached, we had this process operating in many of the vital war plants in the United States, and since then thousands of new plants have been added to the list, which is still growing every day.

INCREASING CUTTING SPEEDS

So far only tool-life increase has been considered. However,

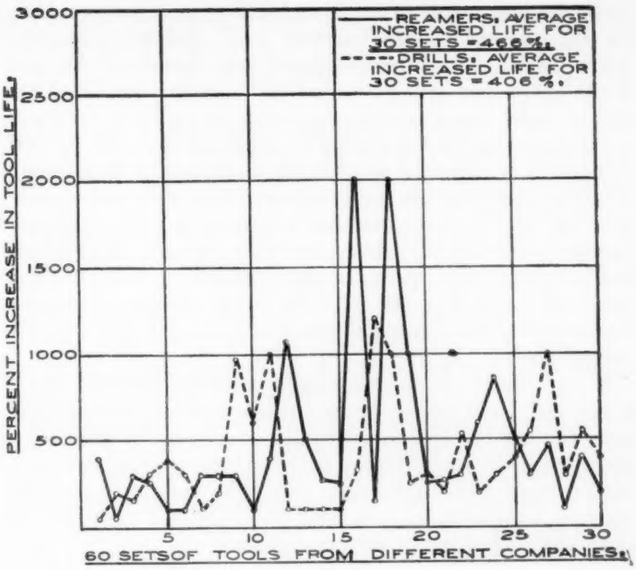

FIG. 1

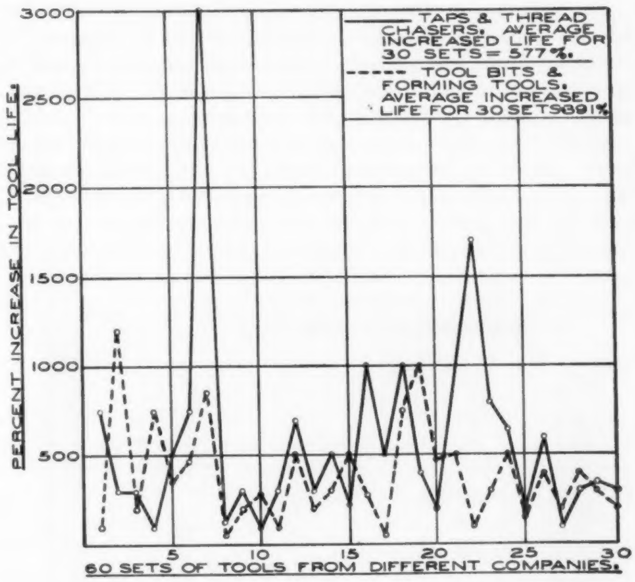

FIG. 2

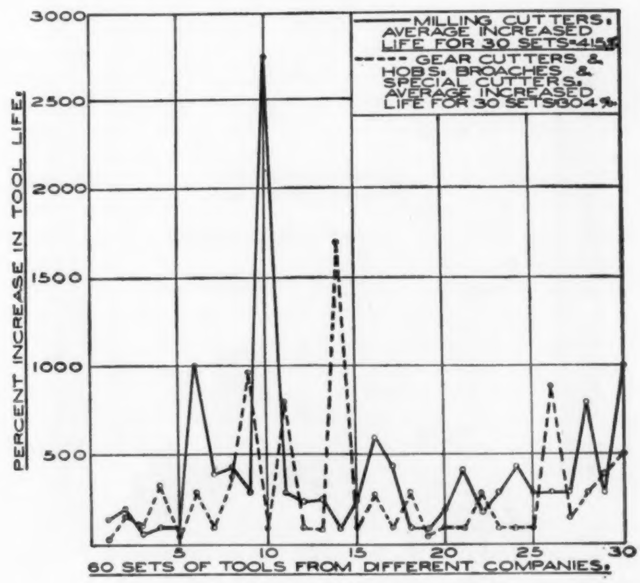

FIG. 3

many concerns were not only interested in increasing tool life, but they wanted increased surface speed, and when that was accomplished, they wanted increased feed. Several of the tools in the charts not only gave increased tool life, but speed and feed as well. For example, one company had been told that we thought we could increase its milling-cutter life 3 times. At first the management was greatly disappointed because only $2^1/_2$ times increased life was obtained. In checking with them, however, they informed us that it was correct they had only increased tool life $2^1/_2$ times, but they also had doubled the feed as well as the speed, so they thought it was all right, especially when they got much smoother and cleaner cutting. Furthermore, the chromium-plated and treated tool also prevented scoring.

Many tools such as taps, and sometimes reamers, thread gages, and plain gages, can be treated with the process when new, and can be run approximately 3 times the normal life of untreated tools, then stripped of the chrome and replated without grinding. Especially does this hold true for gages. We know of treated gages that have now operated more than 50 times the normal life of untreated gages.

LESS HEAT DEVELOPED BY PLATED AND TREATED TOOLS

The plated and treated tool, according to many authorities, has a lower coefficient of friction, which accounts for most of the increase in tool life, smoother and cleaner cutting, as well as prevention of scoring. With less friction, less heat is developed, and consequently longer tool life is achieved.

The less-heat theory was demonstrated to us in plating dental burrs. Never will the author forget the look on the dentist's face after a long burst of drilling: "Have you lost your sense of feeling?" he asked. Most emphatically the author had not, and the nerve was alive. The answer to this personal demonstration was that with lower friction coefficient and, consequently, less heat, the lymph fluid in the nerve channel did not expand enough to press out the nerve and develop any pain. Since that first experiment nearly 2 years ago, this result has been confirmed by many dentists throughout the nation. Besides being able to prepare the cavities faster and with more comfort to the patient, the life of these tools has been increased from 10 to 30 times.

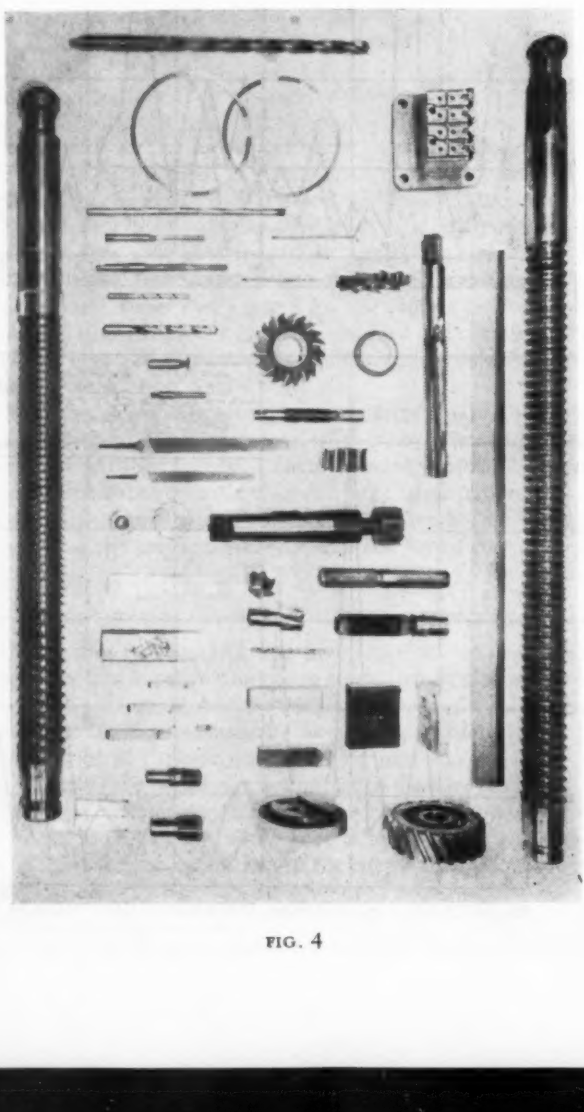

FIG. 4

TABLE 1 MACHINE-PART APPLICATIONS IN PRINTING PLANT

BINDERY	
Juengst Stitcher	
Stitcher dies	Former hooks
Feed-roller holders	Clinchers
Drive bars	Feed rollers
Cover-deck separators	Block cutters
Drivers	Check rollers
Stitcher bars	Gage plates
Cutters	Gage pins
Feed dogs	Tail-clamp pawls
Former dies	Cover-feed dogs
Supporters	Driver dies
Cross Feeder	
Pawls	Tail-clamp ratchets
Feeder ratchets	
Seybold Trimmer	
Knives	Clutch assembly
Router bits	
Dexter Folder	
Delivery feed pawls	Gears
New Jersey Stitcher	
Drives	Side guides
Annels	
Carlyle-Johnson Clutch	
Numerous pieces	Expansion ratchets
COMPOSING ROOM	
Slitting Saws	
PLATE FOUNDRY	
Files	Cutting tools
Band saws	Cutters
Router bits	
JOB BINDERY	
Knurled rollers for Cleveland folder	
LETTERPRESS PRESSROOM	
Press cutting knives for folders and flat deliveries	
GRAVURE PRESSROOM	
Knives	Doctor blades
Knife blades	Roller-bearing sleeves
MAILING	
Gears	Knives
SHIPPING	
Cutters	
STENCIL ROOM	
Punches	

A Canadian manufacturer states: "It is most apparent that the chromium surface not only supports (fortifies) the cutting edge but materially reduces chip friction over the tool. This is confirmed by the nature of the chips and improved finish of the cut. Spindle torque is definitely reduced, as much as 30 per cent on drilling operations, with consequent saving in machine wear (and power consumption)."

Fig. 4 represents the different types of tools that have passed through our laboratory in one day.

After the tools and machine parts have been plated with a few microinches of chromium, it is of vital importance to soak the tool or machine part in hot oil at 350 F for 1 hr. The function of this oil bath is to release the hydrogen which is occluded during the plating. Again repeating, this oil treatment is extremely important. The question might arise: Why not use an air furnace or an inert-gas furnace? We have tried these, but tests have shown that we do not get uniformly good results.

TYPICAL MACHINE-PART APPLICATIONS

After the remarkable success we had in increasing tool life, the process was tried out on many machine parts in our own

(*Continued on page 542*)

NITRIDING HARDENED HIGH-SPEED-STEEL TOOLS

By J. G. MORRISON

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THE performance of a considerable number of high-speed-steel cutting tools may be greatly improved by various surface-altering procedures. The several methods which may be employed are (*a*) chromium plating, (*b*) liquid nitriding, (*c*) surface oxidation, and (*d*) surface oxidation may be imposed on a nitrided surface. Any of these methods may be applied more or less beneficially to any and all types of high-speed steel. These methods are all applied to the finish-treated, or finish-treated and ground tools. While this paper deals primarily with liquid nitriding a comparison of the several methods may be of interest.

In chromium plating, a deposit of the order of 0.0002 in. or less in thickness is made on the ground surface of the tool. There is some difficulty in securing an even deposit of chromium on re-entrant angles unless special-form anodes are used. The chromium plate does not appear to alter the physical properties of the outer layer of the high-speed steel itself to any appreciable extent, provided proper dehydrogenation of the tool is carried out after chromium plating.

In liquid nitriding the tool is immersed in an aged molten cyanide bath in the neighborhood of 1050 F, whereby nitrogen is introduced into the tool surface to form a thin superhard exterior varying from an almost immeasurable depth to 0.004 in. or more. Nitriding exerts a powerful influence on the physical properties of the outer surface of the tool.

The hardness of chromium plate has been measured by Knoop, Peters, and Emerson (1)[1] who report microindentation hardness numbers of 850 to 900. It is possible to secure a nitride case which, when tested by the same method, will show a microhardness number in excess of 1100.

A third method sometimes used is that of surface oxidation. The tool is immersed in an aqueous solution of sodium hydroxide and sodium nitrite (or other suitable oxidizing mixture) at a temperature of about 285 F for from 5 to 20 min. This results in a thin surface layer of black iron oxide (Fe_3O_4).

A fourth method entails liquid nitriding (*b*) followed by a surface-oxidizing treatment (*c*) to produce a blue or black color. Compared to liquid nitriding alone, this method has little merit other than that of sales appeal.

For effective chromium plating or surface oxidation, chemically clean surfaces are requisite. In liquid nitriding such precaution is not necessary. A ground surface is necessary for best results in chromium plating or surface oxidation whereas a ground or unground surface may be nitrided.

The essential good accomplished by chromium plating, surface oxidation or a thin nitride case (approximately 0.0005 in. or less) is to minimize seizure by the tool surface of small fragments of the metal being cut and thereby reduce the friction coefficient. However, some tools when nitrided to case depths of 0.001 in. or more give such a disproportionately greater production over tools less thinly cased that such improvement must be attributed to the great surface hardness over and above the antifrictional quality alone.

All the foregoing methods of surface-treating high-speed-steel tools have their fields of economic application. Such is the great variety of tools used in industry and the mechanical variables to which they are exposed almost infinite, that it is somewhat difficult to predict where each method may be profitably exploited. In general, these methods have their greatest usefulness in tools which take relatively light cuts, and where the tools are not subjected to abnormal shock. High-speed-steel taps are an example of the former, and an extreme example of the latter, where chromium plating or liquid nitriding are of no value, is the case of of high-speed-steel pneumatic chisels used in chipping cast iron.

Pneumatic chisels made of molybdenum high-speed steel adequately treated give excellent performance but the severity of service is such that a chromium plate or a nitride case would spall on the first impact.

Tools which on resharpening are ground on both the rake and clearance angles require replating or renitriding if the hard surface condition is to be restored. This is usually an inconvenience but, since a great number of tools are resharpened on only one of the two surfaces mentioned, the hard surfacing at the cutting edge is thereby maintained throughout the life of the tool.

THE NITRIDING PROCESS

The nitriding process has been described elsewhere (2, 3), and only a brief description will be given here.

Equipment for liquid nitriding may consist of a preheat convected-air furnace with automatic temperature control, and an electrically heated pot furnace with an automatic two-point temperature control. The pot containing the nitriding salt should preferably be made of pressed steel and the thermocouple protection tube of 25 to 30 per cent chromium alloy. Close control of the bath is desirable.

The nitriding bath may be quite expeditiously prepared by heating a mixture of 70 per cent sodium cyanide and 30 per cent potassium cyanide in a pressed-steel pot at 1200 F for 15 to 20 hr. With the top of the pot uncovered, the cyanide will be progressively oxidized to cyanate. From an initial cyanate radical (CNO) content of 1.25 per cent in commercial salts, the aging period will increase the cyanate (CNO) to over 5 per cent, in which condition the bath will produce satisfactory work. Since the atomic nitrogen absorbed by the immersed high-speed steel derives from the cyanate (CNO), a freshly prepared bath is deficient in nitriding capacity; also the nitride cases are brittle probably because of the steepness of the nitride gradient.

Fig. 1 shows the change in cyanide (CN) and cyanate (CNO) concentrations on aging a 70-30 cyanide mixture at 1190 F, in a 35 per cent nickel, 15 per cent chromium-alloy pot. Aging of the salt proceeds more rapidly in an alloy pot than in a pressed-steel pot. As the cyanate increases, the melting point is lowered, and with a cyanate content of 12 per cent the melting point will be about 775 F.

The finish-treated or finish-treated and ground tools are preheated in wire or perforated sheet-steel baskets at from 900 to 1050 F. The baskets are then transferred to the aged molten cyanide bath at from 900 to 1100 F, the temperature depending

[1] Numbers in parentheses refer to the Bibliography at the end of the paper.

Contributed by the Research Committee on Metal Cutting Data and Bibliography and presented at the Spring Meeting, Birmingham, Ala., April 3-5, 1944, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

upon the part to be nitrided. A temperature of 1050 F is most generally used on cutting tools. For certain gages made of high-speed steel, the lower temperatures may be employed. Preheating the tools before immersing in the bath insures a uniform bath temperature as well as prevents spattering of the cyanide by the immersion of parts free from oil or moisture.

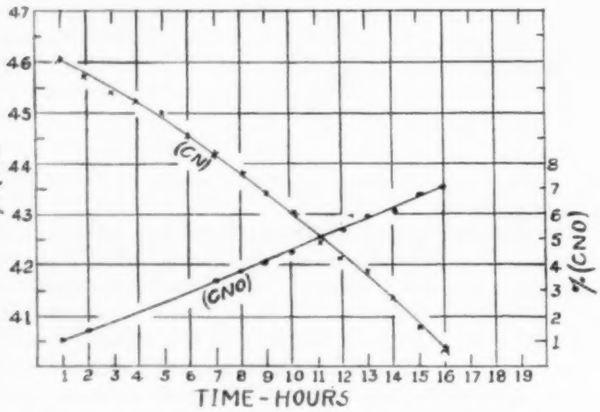

FIG. 1 AGING OF 70 PER CENT NACN-30 PER CENT KCN MIXTURE IN A 10-IN-DIAM × 20-IN. ALLOY POT AT 1190 F
(Pot was uncovered throughout test.)

Nickel-alloy pots and pure-nickel thermocouple protection tubes are best from the standpoint of life, but the bath is an excelent electrolyte and having, as it does, a capacity to dissolve nickel to about 0.008 per cent, this nickel is plated onto the immersed high-speed steel. As nickel is an inhibitor to nitriding as well as contributing a thin soft surface, it is desirable to avoid this condition. Nickel deposited on high-speed steel immersed in a bath contaminated with nickel has sometimes been reported as a "build-up" in carbide (4, 5) at the surface. High-speed steel, nitrided at 1100 F or below, shows the absence of any additional carbide at the surface, and analyses of surface cuts (the only adequate method of exploring this phase) indicates that no carburization occurs.

When high-speed steel is immersed in an aged cyanide bath at the nitriding temperatures, the steel surface catalyzes the cyanate (CNO), and it is split up to furnish, among other things, nascent nitrogen and finely divided carbon. The nascent or atomic nitrogen diffuses at the surface of the steel to form quite stable nitrides, resulting in a great enhancement of the surface hardness. The finely divided carbon deposited on the tool surface acts somewhat as an inhibitor to nitriding, perhaps fortuitously so, in that an inordinate amount of nitrogen is not supplied to the steel surface. When speed steel is gas-nitrided, an excessive amount of nitrogen does appear to be absorbed, and again brittle cases ensue, because of the high concentration of nitrides at the steel surface.

SURFACE ATTACK OR "WASHING" IN NITRIDING

In nitriding, the high-speed steel is attacked to some extent. The surface attack or "washing away" of surface metal is dependent upon time of immersion, temperature, cyanate concentration, and perhaps to nickel contamination when present. With a cyanate (CNO) content of from 8 to 12 per cent and for immersion times of 2 hr or less, the surface attack for most practical purposes is negligible. Fig. 2 (6) shows the relative effects at 1050 F of cyanate (CNO) concentration, and of time, on the loss of surface metal; also the relatively lesser loss for a period of 30-min immersion time when the specimens are electrically insulated. For immersion periods of less than 30 min, a gain in weight may occur. The specimens from which the data in Fig. 1 were obtained were made of 0.70 carbon 18-4-1 high-speed steel hardened from 2350 F, and double drawn at 1050 F for $1^1/_2$ hr. Specimens approximating $^3/_8$ in. × $^1/_2$ in. × 1 in. were ground and polished on all six sides before nitriding. After nitriding, all specimens were cleaned to a metallic surface condition. Specimens before and after nitriding were cleaned and weighed on an analytical balance.

INFLUENCE OF PRIOR SURFACE STRUCTURE ON NITRIDING AND MICROSCOPIC NATURE OF THE CASE

High-speed steel is in the most favorable condition for nitriding when no residual austenite is present. Any high-speed-steel tools hardened under such conditions, where an excessive

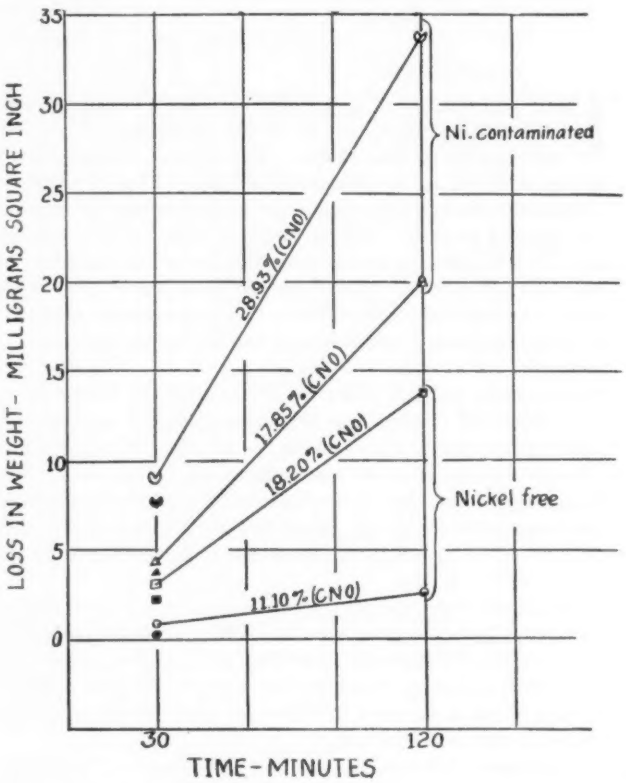

FIG. 2 EFFECT OF TIME AND OF CYANATE (CNO) CONCENTRATION AND CYANATE CONCENTRATION PLUS NICKEL CONTAMINATION ON SURFACE-LOSS OF METAL WHEN 18-4-1 HIGH-SPEED STEEL IS NITRIDED AT 1050 F; ALSO COMPARISON OF NONINSULATED (OPEN SYMBOLS) AND INSULATED (CLOSED SYMBOLS) SPECIMENS NITRIDED AT 1050 F FOR 30 MIN

amount of carburization occurs, may be poor subjects for nitriding. If an excessive amount of carbon has been absorbed at the surface in hardening, and a high-carbon high-alloy austenite is formed, it is possible that this austenite (particularly so in the case of molybdenum high-speed steel) may not be decomposed in the tempering operation. A highly austenitic surface will prevent the ingress of nitrogen; this is probably because the crystal lattice is thoroughly filled in its available interstices by carbon.

There are no evident microstructural changes brought about by nitriding. When etched in 4 per cent nital or similar etchant, there is only a color difference, the nitride case darkening much more rapidly than the "core" metal.

For "flash" cases, a result of nitriding for as little as 5 min, the case depth may be hardly discernible under the microscope, and a broken test file is as good as anything else for practical exploration of the surface hardness. High-speed steel, nitrided for about 30 min at 1050 F, will show a measurable microscopic case depth of approximately 0.0012 in. In 6 hr, a case depth of 0.004 in. may be secured. Actual penetration of the nitrogen and some enhancement of hardness extends a little distance below the microscopically measured cases. A period of 5 min to 2 hr probably encompasses the immersion times given the greatest percentage of tools nitrided

TABLE 1 COMPARISON OF IZOD-IMPACT TESTS (UNNOTCHED BAR) MADE ON 0.70 CARBON 18-4-1 AND 0.80 CARBON 5.5 W-4.5 MO-1.5 V HIGH-SPEED STEELS NOT NITRIDED AND NITRIDED AT 1050 F, FOR VARIOUS PERIODS OF TIME[a]

	Not nitrided			Nitrided 10 min			Nitrided 30 min			Nitrided 1 hr			Nitrided 2 hr	
Specimen no.	Rock. "C"	Izod	Specimen no.	Rock. "C"	Izod	Specimen no.	Rock. "C"	Izod	Specimen no.	Rock. "C"	Izod	Specimen no.	Rock. "C"	Izod
P-20	64.0	43.0	P-23	64.1	12.5	P-10	64.1	8.0	P-13	63.9	7.0	P-16	63.5	6.0
P-21	64.1	29.0	P-24	64.0	12.0	P-11	64.0	8.0	P-14	63.9	7.0	P-17	63.8	7.0
P-22	64.0	39.5	..[b]	..	..	P-12	63.5	7.0	P-15	63.8	6.5	P-18	63.6	6.5
M-19	65.2	34.0	M-22	64.9	11.5	M-10	64.1	10.0	M-13	63.9	7.0	M-16	63.9	8.0
M-20	65.4	51.0	M-23	64.9	12.0	M-11	64.2	10.0	M-14	63.9	8.5	M-17	64.0	8.0
M-21	65.4	24.0	M-24	65.0	11.5	M-12	64.1	8.0	M-15	63.8	8.0	M-18	63.9	8.0

[a] Specimens denoted as "P" are 18-4-1 steel; "M" specimens are molybdenum high-speed steel.
[b] Only two samples this group.

HARDNESS OF NITRIDE CASE

Because of the superficial depth of the nitride case, the usual commercial methods of hardness-testing are inadequate for estimating accurately the increment in surface hardness.

The Vickers hardness test using loads of 10 kg or less gives a fair estimate of the surface hardness, although the malformation of the square impressions does not make for a high degree of accuracy. The Tukon tester, employing the Knoop indenter, is the most searching method of gaging the surface hardness. The maximum surface-hardness number of about 1125 is indicated by the Knoop test and may be obtained in from 1 to 2 hr immersion at a temperature of 1050 F. Electrically insulating the immersed high-speed steel favors the achievement of maximum surface hardness in less time than when the steel is not insulated.

In cutting tools, the maximum surface hardness is not usually desired, and a nitriding period of from 15 to 30 min is most common. Where wear resistance is the primary consideration, as in large heavy-duty lathe centers and for certain gage fixtures, the maximum surface hardness is usually sought.

EFFECT OF NITRIDING ON IMPACT TESTING AND BEND TESTING OF HIGH-SPEED STEEL

While there is no genuine correlation between the impact values of high-speed steel and cutting performance, and the literal acceptance of impact data apt to mislead one to make poorer rather than better tools, some such data are included here for academic purposes and for the little information they may yield.

(*a*) *Impact Tests.* Impact values, such as in the Izod test, are obtained, in the case of high-speed steel, on unnotched test samples. Assumptively, the specimens absorbing the most foot-pounds when broken under impact should be "tougher" than those absorbing only one half or one quarter the number of foot-pounds. The test, however, is of such severity that neither good nor bad tools could be used under such conditions of impact. The test yields no information of the ability of the steels to withstand the moderate small impacts normal to use. High impact values in testing high-speed steel result in the tempering of the primary martensite and the retention of austenite such as occurs in drawing at 700 to 900 F. Good tool performance depends upon the relative freedom from austenite and the tempering of the secondary martensite.

The function of a cutting tool is to remove metal. Toughness, in the sense that under impact the tool may "give" a little and return to the normal cut again, is contrary to the proper functioning of the tool. Rigidity, rather than the usually conceived toughness, is required of a tool, if it is to "stay put" and remove metal. Because of this circumstance, many nitrided tools give phenomenal performance over similar tools not nitrided, even though the impact values of the former are considerably lower.

Table 1 shows the relative Izod impact values of nitrided and nonnitrided high-speed-steel specimens. The 18-4-1 steel specimens listed in Table 1 were hardened at 2335 F, 1 min 45 sec from salt-bath furnaces, quenched into a molten salt bath at 1200 F for 45 sec, followed by cooling in air. The molybdenum high-speed steel specimens were similarly treated, except the superheat temperature was 2200 F, 2 min. All specimens were then double-drawn at 1050 F, for $1^1/_2$ hr and accurately ground to size. The specimens nitrided at 1050 F were so processed after grinding.

(*b*) *Bend Tests.* In the bend test employed, the test specimens were 0.500 in. plus or minus 0.0005 in. $\times$ 0.140 in. plus or minus 0.0005 in. $\times$ $2^1/_4$ in. long. These were broken between centers 2.062 in. apart at room temperature with pressure applied at approximately 500 lb per min. The maximum deflection was noted on breakage and, from the maximum load in breaking, the maximum fiber stress in tension was calculated.

For brevity, a composite analysis of the three heats of molybdenum high-speed steel employed is given, as well as the composite or averages of all specimens tested in each group. Composite specimens "A" to "D" inclusive are each averages of six different specimens, and composite specimens "E" and "F" are each averages of three different specimens.

All specimens approximately 0.008 in. oversize were hardened from salt-bath electrode furnaces, being preheated at 1500 F, 5 min, superheated at 2200 F and at 2260 F for several periods of time (as shown in Table 2), quenched in a salt bath maintained at 1200 F for 45 sec, finish-cooled in air. Specimens were double-drawn at 1050 F for $1^3/_4$ hr, and then ground accurately to size, the nitrided specimens being processed after this operation.

The composite analysis of the steels employed is as follows:

C	Mn	Si	Cr	W	V	Mo
0.80	0.32	0.33	4.20	5.61	1.52	4.63

A comparison of both the deflection and calculated maximum fiber stress shows the nitrided specimens to have about one half the values of the specimens not nitrided. This difference between nitrided and nonnitrided specimens of high-speed steel under the static bend test is much less than that found under the dynamic Izod test. Also the nitrided specimens hardened from 2200 F for 1 min 15 sec show values superior to the specimens not nitrided but hardened from 2260 F, 2 min 30 sec. This comparison is not entirely justified except that in our work-a-day world there are many tools made of molybdenum high-speed steel hardened from 2260 F for 2 min 30 sec or more and which give

TABLE 2 COMPARISON OF MAXIMUM DEFLECTION AND MAXIMUM FIBER STRESS IN BEND-TESTING QUENCHED AND DRAWN; AND QUENCHED, DRAWN, AND NITRIDED MOLYBDENUM HIGH-SPEED STEEL

Composite-specimen designation	Superheat Temperature, deg F	Superheat Time, min-sec	Nitriding 1050 F	Rockwell "C"	Maximum deflection, in.	Calculated maximum fiber stress, in-lb
"A"	2200	1–15	None	65.1	0.1227	624000
"B"	2200	2–30	None	65.4	0.1083	576000
"C"	2260	1–15	None	66.4	0.0821	441000
"D"	2260	2–30	None	66.1	0.0562	294000
"E"	2200	1–15	10 min	64.8	0.0657	366000
"F"	2200	1–15	30 min	64.6	0.0607	330000

excellent service, yet such tools may possess properties, as herein considered, inferior to some nitrided tools.

About the most weighty conclusion we may draw from the impact and bend-test data in regard to nitriding is that, if our tools are already giving poor performance because of excessive impact, misalignment, or other faulty mechanical conditions, nitriding may lower rather than improve cutting performance.

PRACTICAL APPLICATION OF NITRIDED HIGH-SPEED STEEL

Nitriding may sometimes be used as a corrective to abusive but not ruinous grinding, i.e., in those cases where some softening has occurred in grinding, nitriding may restore the surface hardness to a greatly improved tool life.

High-speed-steel taps may often be improved by nitriding. However, if the taps are showing poor life because of misalignment, nitriding may aggravate rather than improve the performance. Sometimes the taps may be too soft or may have had the thread crests damaged in grinding. Nitriding under these conditions often results in a remarkable improvement in performance.

Nitriding is applied to some extent on twist drills, and many are furnished in this condition. On twist drills, the nitrided surface after sharpening is on the cutting face (or on the spiral flutes), whereas on the tap, after sharpening, the nitrided surfaces are on the clearance faces. It is perhaps desirable on fine-edged tools to have the nitrided surface on only one face area in order to minimize edge brittleness.

Single-point tools used in threading or in forming, where a good finish is required, often show a marked improvement in life after nitriding for 30 min to 1 hr.

It has been our experience that milling cutters and shaper tools, generally, have not shown much improvement after nitriding. Some milling cutters, however, used on soft free-cutting steels, cast iron, and weak abrasive materials have shown at times double or triple increase in production. Shaper tools used in cutting heat-treated steels have shown little or no improvement, but in cutting cast iron a ninefold increase has been observed.

The case history of a small hob made of 5.5 per cent tungsten, 4.5 per cent molybdenum, and 1.5 per cent vanadium may be of interest. This four-fluted hob about $^5/_8$ in. diam was used in hobbing a quarter 8-pitch square thread, 0.0625 in. in depth in 18-4-1 high-speed steel. From 0.0015 in. to 0.0025 in. was removed on each pass. For some years, 1.10 per cent carbon tool steel was used in making the hobs since almost perfect sharpness of the tool is required throughout the cutting because of the absolutely square thread it had to generate.

The average performance of the carbon-steel hobs was 15 pieces, 3 in. long. The molybdenum high-speed-steel hobs were heated in electrode salt-bath furnaces, quenched and drawn to 65 Rockwell C under conditions to insure a reasonably well-treated tool. In service the hobs produced from 2 to 3 passable threads per grind. These same hobs nitrided at 1050 F for 20 min gave an average per grind production of 27 pieces. Several hobs from the same lot after nitriding for 1 hr produced an average of 73 pieces per grind over the entire life of the hobs. While this is an unusual case and the machining operation more of a nibbling one, nevertheless, it is quite difficult to form a square thread, and the percentage improvement effected by nitriding is striking. When wear accompanied by some frictional heat is encountered as in heavy-duty lathe centers made of high-speed steel, nitriding at 1050 F for $1^1/_2$ hr has shown a consistent improvement in life of 3 to 4 times.

The evaluation of the benefit of liquid nitriding may sometimes be compromised by the use of a salt-bath-quenching procedure whereby a nitriding takes place on the quench. High-speed steel given an interrupted quench into a molten salt bath (at 1100 to 1200 F) containing cyanide will absorb some little carbon and nitrogen. After drawing, the surface will be superhard because of the higher carbon it contains, as well as to the nitrides formed. It may be noted that although some carburization occurs on quenching from the hardening heat into a molten bath containing cyanide, it does not follow that a reheat in cyanide at 1100 F or lower will effect a carburization.

SUMMARY

Liquid nitriding of hardened high-speed-steel tools appears to have its greatest field of usefulness when applied to those tools which take relatively light cuts, and where impact and other mechanical disadvantages are moderate.

To obtain a consistently good product, proper control of the nitriding bath as to temperature and composition is requisite.

The adverse effect of nitriding on the impact and bend properties of high-speed steel is no criterion of the general value of nitriding. Such tests do indicate that tools already operating under unfavorable conditions of impact, misalignment, etc., may show poorer rather than better performance when nitrided.

Liquid nitriding of high-speed-steel tools has been in commercial use for about 10 years. During this period, there has been a considerable growth in the application of this treatment. It is believed that the future will show a continued and extended use of the process to those tool applications for which it is adapted.

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6 Data developed by J. G. Morrison and J. P. Gill, Chief Metallurgist, Vanadian Alloys Steel Company.

Cutting-Tool Performance

(*Continued from page 538*)

plant. Table 1 is a list of a few of the parts treated in our plant with an increase of from 50 to 900 per cent.

In the spinning and weaving industries, by means of this process, the life of many parts has been increased, but what is most important, production has been increased, due to the fact that the parts operate much more smoothly with less friction. Because of this smoothness of operation, there is not so much breakage of the thread, and consequently the output is greater.

In sewing nylon parachutes and camouflage clothes, the same holds true. In small-caliber gun barrels, it has been proved that some increase in barrel life can be expected. The life of gears, cams, slides, and many other items can also be increased.

AN INVITATION TO MANUFACTURERS

As previously mentioned, this process can be obtained by manufacturers engaged in war work, royalty free for the duration. The only requirement is to write to Mr. Thomas H. Beck, President, The Crowell-Collier Publishing Company, 250 Park Avenue, New York 17, N. Y., asking permission to use this process. At the same time, several different tools, two or three of each kind, should be sent to Axel Lundbye, The Crowell-Collier Publishing Company, Springfield, Ohio. We will plate and treat them, and return them for tests. Should the tests be satisfactory, one or more men can be sent to our laboratory to see the process in operation. It is simple and the equipment is inexpensive. We will be glad to act as consultant as long as a company deems it necessary. There are no charges. All we ask is that the results of tests be supplied to us.

Notes on Recent TRENDS *and* USES *of* ALLOY STEELS

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A TREND in the composition of alloy steels, that has been markedly accentuated by the war, had been in progress for a number of years prior to the war. This trend is in the direction of utilizing to the maximum the alloying elements. It consists in reducing the amount of a given element used and the extended use of several elements in relatively small amounts in a steel. As might be expected, variation in alloying contents required some modifications and changes of heat-treatment. The trend in heat-treatments often consisted in using more drastic quenches for the purpose of promoting hardenability in steels in which this property was less pronounced. The changes of quenching lay in the direction of air to oil to water; and in some cases brine quenches are required to induce a desired extent of hardenability in a given section.

The conservation of alloying elements that was being made prior to the war was dictated by sound metallurgical practice and a desire to effect all possible economies.

With the advent of war the need for alloy steels was vastly amplified, and the demand increased more rapidly than the production rate of the alloying elements. Hence it became necessary to reduce as far as possible the quantity of each alloying element used. In this connection, Table 1, giving a comparison between 1937 steel statistics and those of 1942 and 1943, should be enlightening.

TABLE 1 COMPARISON OF 1937, 1942, AND 1943 STEEL PRODUCTION

1937	56,636,000 tons of steel produced
	3,396,000 tons of alloy steel produced
	6 per cent of alloy steel produced
1942	86,032,000 tons of steel produced
	11,000,000 tons of alloy steel produced
	12.6 per cent of alloy steel produced
1943	89,100,000 tons of steel produced
	13,500,000 tons of alloy steel produced
	15.15 per cent of alloy steel produced

The upward trend of the amount of alloy steel produced furnishes a clue to the source of shortage in alloying elements.

The conditions indicated by Table 1 have resulted in a series of "National Emergency" (N.E.) steels, which, in some cases, are lower in alloy content than similar S.A.E. steels. These steels have provided good substitutes for many of the prewar alloy steels. In many cases their manipulation requires more concentrated attention than was necessary with the prewar steels. Undoubtedly many of the steels of low alloy content will remain after the war, and the more exacting heat-treating requirements they now impose will be reflected in a general improvement in this art.

The composition of the N.E. steels has varied as certain alloying elements have varied in degree of scarcity. It has also been affected by the property of certain elements such as nickel and molydenum, of remaining permanently in steel, and therefore when returning with scrap, to reappear anew in the subsequent steel. As the level of residual elements tends to become constant, the compositions of the N.E. steels will become more nearly fixed.

Steels are alloyed for a number of reasons, among these may be mentioned the following:

1 Improvement in mechanical properties, including control of hardenability.

2 Modification of physical properties, such as coefficient of expansion, electrical properties, etc.

3 To create resistance to corrosive attacks by acids and oxidation.

The use of alloys to improve mechanical properties and to control hardenability is perhaps the most important.

IMPROVEMENT OF MECHANICAL PROPERTIES

Air-Cooled Steels. Alloys are added to improve the strength and other mechanical properties of steel in the air-cooled as well as in the conventionally heat-treated (quenched and drawn) conditions.

Perhaps one of the most spectacular trends in the use of alloy steel has been in the low-alloy constructional steels.

The importance of a constructional material appears to reside in the strength-to-weight ratio. It is generally desirable, within certain limits, to have a minimum of weight with a maximum of strength. In some applications, such as locomotives, a certain weight is necessary to make the strength effective; however, in most cases lightness is an important asset if it does not sacrifice unit strength. Certain of the work-hardening austenitic stainless steels have a remarkably high strength-to-weight ratio.

Alloy constructional as well as carbon steels are largely a mixture of ferrite (pure iron) and carbides (carbon combined with iron and with certain alloying agents). The alloying agents influence the strength of the steel by acting upon these two components. Certain elements, such as nickel, copper, silicon, and aluminum, seek out the ferrite, while manganese, chromium, tungsten, molybdenum, and vanadium seek the carbon. These latter elements are referred to as carbide formers. The carbide formers when unable to satisfy their natural bent act upon the ferrite. The result is that all of the elements just cited are effective in strengthening low-carbon steels and are used to form the important structural steels already mentioned.

Carbon is the most potent of all elements for increasing the hardness and strength of iron; however, deficiencies in other properties, such as ductility and weldability, curtail its use. By using small quantities of alloying elements with steels of low carbon content, consistently good mechanical properties and, in the case of nickel steels, good welding qualities are secured in rolled shapes.

Composition of some commercial-alloy constructional steels is given in Table 2.

It has appeared essential for some time to have available constructional steel that can be welded without preheating or postheating. An investigation was undertaken at the U.S. Bureau of Standards by Ellinger, Bissell, and Williams, and the

Contributed by the Iron and Steel and Welding Divisions of the Metropolitan Section and presented at a meeting of the Section, New York, N. Y., March 29, 1944, of The American Society of Mechanical Engineers.

TABLE 2 COMPOSITION AND PROPERTIES OF LOW-ALLOY CONSTRUCTIONAL STEELS

Type	C	Mn	Si	Ni	Cu	Cr	Mo	V	Yield point, psi	Tensile strength, psi	Per cent elongation in 2 in.	Per cent elongation in 8 in.	Uses
Silicon	0.40 max	1.00 max	0.20 min	...	...	...	...	...	45000 min	80/95000	...	16 min	Bridges and buildings
Manganese	0.15/0.35	0.90/1.75	0.15/0.30	...	[a]	...	...	...	55000 min	90000 min	20 min	...	Miscellaneous structural purposes; high-strength rivets
Mn-V	0.18 max	1.45 max	0.25 max	...	...	...	...	0.08/0.14	50000 min	85000 max	...	20 min	Ship plate
Ni (2 per cent)	0.20 max	0.80 max	0.15/0.30	2.00/2.75	...	...	...	...	45000 min	75000 min	...	20 min	Locomotive boilers; low-temperature welded pressure vessels
Ni (3½ per cent)	0.45 max	0.80 max	0.30 max	3.0/4.0	...	...	...	...	45/57000	90/115000	...	14 min	Bridges
Cr-Mn-Si	0.17 max	1.05/1.40	0.60/0.90	...	[a]	0.30/0.60	...	...	45/54000	75/90000	...	18 min	Pressure vessels and miscellaneous equipment
Molybdenum	0.18 max	0.50/0.90	0.10/0.30	...	...	...	0.40/0.60	...	37/43000	65/77000	...	21 min	High-temperature vessels; welded structures
Rimmed carbon steel	0.25 max	0.90 max	...	...	[a]	...	...	...	30000 min	60000 min	22 min	21 min	Structural purposes

[a] When specified, 0.20 per cent min.

results were subsequently published.[1] In the investigation reported, steels of 70,000 psi tensile, 50,000 psi yield, and elongation of 20 per cent in 8 in. were examined. The outstanding steel appears to be No. 146, which contains 0.10 per cent carbon, 1.90 per cent nickel, and 1 per cent copper. In the summary of the work it is said: "Steels containing nickel and copper had the highest welding qualities of the steels tested."

In general the copper steels with suitable nickel additions to maintain the copper in solution during hot-rolling meet best the qualifications for low-alloy constructional steels; namely, good ultimate strength, high yield-to-ultimate ratio, ease of fabrication, improved corrosion resistance in many media over that obtained from carbon steels, and good welding qualities. The good welding qualities are associated with the low carbons of many of the copper-nickel alloy steels.

The low-alloy structural steels find application in freight and passenger cars, tank trucks, power shovels, cranes, and in other applications where strength and lightness can profitably be combined. Because of excellent properties, the alloys containing nickel were especially applied to the services mentioned. Many of the listed uses have been curtailed during the war.

There had been a marked trend prior to the war to use alloy steels for locomotive boilers. The 2–3 per cent nickel steels with 0.20 per cent maximum carbon, as well as "silicon-manganese" steel, were finding increasing employment in this service.

There is a growing realization that welding will have to be applied to locomotive boilers if steam pressures higher than about 275 psi are to be used. Work on this subject is progressing slowly.

As a contribution to the subject of welded locomotive boilers a prominent manufacturer of locomotives, in collaboration with the author's company, carried out some welding tests on a carbon and a nickel locomotive-boiler steel. The test data are summarized in Table 3.

The use of low temperatures in petroleum refineries and for the storage of natural gas in liquid form has increased the use of 2½ to 3½ per cent nickel constructional steels. Some nickel-copper-chromium alloy steel has also been used. The benefits to be derived from a contraction of gas volume of 600 to 1 will undoubtedly spread the storage of gases in liquefied form.

One of the most interesting trends before the war was toward the wider use of the high-strength, corrosion-resistant, stainless steel of approximately 17 per cent chromium 7 per cent nickel (also 18 per cent chromium, 7 per cent nickel). As previously mentioned, this alloy by virtue of its ability to be cold-worked can gain very high strengths,[2] and therefore when properly treated possesses a high strength-to-weight ratio.

The 17–7 alloy was being widely used for bodies of freight trucks, and streamlined cars and trains. Interest was also shown in this alloy for plane construction. The use of the 17–7 alloy is expected to be greatly increased after the war.

Normalized Parts. A common use of alloys is to give good mechanical properties to forgings too large or complicated for treatment other than by normalizing. Normalizing consists in heating to a temperature approximately 100 F above the critical temperature and cooling in still air.

Two to three per cent nickel, chrome-nickel, nickel-molybdenum, carbon-vanadium, and manganese-vanadium steels are types finding application in many fields including railroad, petroleum, and power fields. The large drill collars and kellys uesd in petroleum production are examples of normalized forgings of X-3140, a nickel-chromium alloy steel. The ends are usually quenched.

TABLE 3 SUMMARY OF RESULTS OF SOME WELDING TESTS CARBON AND NICKEL STEEL BOILER PLATE

Steel	Mark	Plate composition, per cent: C	Mn	Si	Ni	P	S
Carbon	C	0.21	0.29	...	...	0.014	0.031
Nickel	N	0.17	0.51	0.21	2.43	0.015	0.029
Nickel (check)		0.19	0.53	0.21	2.38	...	...

The plates were welded with electrodes suitable for the composition. The deposit in the nickel-steel plate showed the following:

	Composition, per cent, of deposit—Ni electrode				
Weld metal	0.08 C	0.51 Mn	11 Si	1.89 Ni	0.20 Mo

(The nickel in the deposit was lower than anticipated but apparently did not adversely affect the mechanical properties of the weld. All welding was executed in the flat position without preheating and without peening.)

Mechanical properties specified for plates

Specification: Carbon steel—AAR M-115-38
Nickel steel—ASTM—A-203-42 (B)

	Carbon steel	Nickel steel
Tensile strength (ts)	55/65000 psi	70/82000 psi
Yield strength	0.5 (ts)	0.5 ts 40000 min
Elongation, per cent in 8 in.	$\frac{1500000}{ts}$	$\frac{1650000}{ts}$

Radiographic Examination. Both plates were subjected to X-ray examination before cutting. As a further precaution, after stress relief, the test pieces were X-rayed. All the X-ray negatives showed sound welds.

Stress Relief. Stress relief was carried out at 1150–1175 F.

[1] "Tee-Bend Test to Compare Welding Quality of Steel," by G. A. Ellinger, A. G. Bissell, and M. L. Williams, U. S. Bureau of Standards, *Journal of Research*, vol. 28, no. 1, January, 1942, RP 1444.

[2] "Tensile and Compressive Properties of Some Stainless-Steel Sheet," by C. S. Aitchison, Walter Ramberg, L. B. Tuckerman, and H. L. Whittemore, U. S. Bureau of Standards, Research Paper 1467, April, 1942.

HEAT-TREATED ALLOYS

The mechanical properties of alloy steels can be greatly affected by suitable heat-treatment.

The present paper is concerned only with heating, quenching, and drawing to improve mechanical properties.

As alloy steels developed, there gradually appeared a classification of the greatest importance known as the S.A.E. classification and charts of steels so classified were prepared to show the response of the mechanical properties to draw temperatures. For each steel, that is, for each ten points of carbon in a series, a chart had to be prepared. This involved considerable work. Fortunately, extensive knowledge of the interrelationship of properties of a steel existed so that when the war broke a fair-sized body of empirical and scientific knowledge was available for use. This proved of inestimable value when the N.E. steels were appearing since it permitted an evaluation of these steels without the tedious and long-drawn-out work associated with preparing a chart.

Fortunately, a property of heat-treated steels that has received the greatest attention during recent years is hardenability. This may be defined as the tendency of the hardness of the quenched surface to extend into the metal. If the hardness is plotted against depth of penetration, the slope of the line measures hardenability. As the slope approaches zero, the hardenability increases. The importance of hardenability had been especially appreciated by metallurgists in the automotive field, and since the automotive steels were the ones most likely to be replaced, the first data offered in connection with the N.E. steels were those bearing on hardenability.

Evaluation of Hardenability. Evaluation of hardenability can be made by a number of means. The most direct method is to quench a round, then cut across and make a hardness plot. There is some danger that the heat generated in cutting the specimen will tend to temper it.

In passing, it should be mentioned that the classical consideration of hardenability deals with a cylinder whose center is just 50 per cent hardened by the treatment given, i.e., 50 per cent is martensite. Hardenability is evaluated in terms of the diameter of the cylinder—the greater the diameter the greater the hardenability.

Grain size is a controlling factor in hardenability, and apparently the greater the grain size the greater the hardenability for a given composition and heat-treatment. This factor has to be considered in the tests to be discussed. Coarse grain size, conducive to high hardenability, is rarely desirable, and hardenability is preferably secured through the use of alloying elements. The use of aluminum and other means of controlling grain size is one of the most important trends in steel metallurgy that has been noted in the last decade.

The Jominy Test. Of the various hardenability tests, the Jominy test is probably the best known and most widely used. This test is viewed as a real contribution to metallurgy and is of the greatest value in designing a part from a given steel, or evaluating a steel part already made up.

The test is fairly simple and results appear to be readily reproducible. The chief merits of the tests appear to center around its simplicity and the great amount of related data associated with it. The test consists in water-quenching, under controlled conditions, the end of a specimen made to standardized shape. The specimen before being placed in a jig for cooling is heated to a hardening temperature. When cold, the specimen is ground along a side, and a hardness survey is made on the ground face. Hardnesses resulting from the quench, from somewhat accelerated cooling, and from cooling in air, are to be found in the specimen, and the results form a curve when hardness is plotted against distance from the quenched end.

Hardness-Cooling-Rate Tests. In connection with the Jominy hardness tests, the hardness versus "cooling rate" test is quite important. Hardness - cooling-rate curves are drawn from the results. To illustrate the use of the hardness-cooling-rate curves in connection with the Jominy test an example is offered which involves the design of a gear.

Assume we have a steel for which the hardness-cooling-rate curve has been plotted. We have chosen this steel because from hardness transverse tests we know it is shallow-hardening. We make a dummy gear from this steel and give it the heat-treatment the final gear will receive. We section the dummy and take Rockwell readings which are recorded. From the hardness-cooling-rate curve for the dummy steel, we read cooling rates in terms of hardness.[3] We now have cooling rates at the surface and at points inside the body. Two choices of procedure are available:

1 We can examine Jominy results for many steels in which hardness is plotted against distance from the quenched end and also against cooling rates. The latter is important to us. From this examination we may select a steel meeting the requirements which may be Rockwell C 55 at 75 F per sec for a point near the surface and Rockwell C 45 for a point near the center where the rate is 25 F per sec.

2 We could have compared the desired results with hardness-cooling-rate curves directly instead of using the Jominy results. The Jominy results are more plentiful and easier to obtain than hardness - cooling-rate curves.

If the steel had been such as to require an oil quench which would have changed the cooling rates, we would find that a correlation between data from Jominy tests and oil-cooled parts exists, and we would use these data.

There appears to be no end to the usefulness of the data obtained from the Jominy tests since it ties in with such a mass of other data. If we desire to know the strength at some point in a part, we can make a Jominy test of the steel involved, estimate its hardness at the point under investigation, and from the hardness data evaluate its strength and other properties. Case-hardened parts require special consideration.

To illustrate how far metallurgical science has progressed, Grossmann has offered a method of computing hardenability from the composition of a steel, and Craft and Lamont have extended his works. His works can be correlated with the Jominy test and related data.

Hardness in Relation to Physical Properties. Considerable emphasis on hardness as well as hardenability is made in connection with the N.E. steels. This appears to be justified if one considers hardness in connection with other mechanical properties. From the works of Janitsky and Bayertz, also of Patton, it appears that most fully hardened alloy steels drawn to a certain hardness value will possess the same ultimate strength, yield point, elongation, reduction of area, and impact value. This association of properties only holds where the Brinell hardness values lie between 250 and 400 Bhn and, as pointed out, applies to steel sections fully hardened. The importance of the various alloys lies in controlling the hardenability, i.e., size of section uniformly hardened.

As has been mentioned before carbon is the element most important in giving hardness to iron. In fact it may be said that carbon provides hardness in steel and alloys confer hardenability. This can be explained by the fact that hardness is due to the dispersion of the carbon, and alloys control the transformation rates, hence control the dispersion.

Briefly, to harden a steel it is heated to a range where the normal alpha form of iron crystals transforms to the gamma form. Carbon is feebly soluble in the alpha form and quite soluble in the gamma form; it therefore goes into solution. The piece is cooled and carbon is precipitated. If caught just as it precipitates martensite is formed, which represents the fully hardened form of steel.

Davenport and Bain have made especially important studies of the transformation rates of steels under isothermal conditions.

[3] The assumption is that all compositions of steel will cool at about the same rate. It is considered that the shape controls the cooling rate.

Their studies have resulted in the now famous "S" curves and in a greatly increased knowledge of the mechanism of transformation. Their work has been one of the most brilliant contributions to metallurgy in the past several years. The practical applications to quenchings are now being felt.

Summary. The trend noted in the heat-treated steels appears to be toward complex alloys of high hardenability of which the nickel-chromium-molybdenum alloy steel 4340 is an excellent example. The necessities of war have forced the use of lean alloy steels. Many of these contain three or more alloying elements which is in keeping with the trend.

In general it appears that the trend in alloy steels has been a pronounced increase in the use of low-alloy constructional steels prior to the war. The effects of the war have been to widen the use of low-alloy steels and to extend them into the field of heat-treated steels. The N.E. steels introduced by the war are too new to allow an attempt at predicting their position in the era following the war. The indications are that some of these emergency steels will occupy a permanent place.

FATIGUE

Of the many properties of steel affected by alloys, the endurance limit is one of the most important. The endurance limit is the stress above which fatigue failure can occur and below which no fatigue failure is to be expected. The value of the endurance limit is usually from 45 to 60 per cent of the ultimate strength of highly polished and carefully handled specimens.

In actual practice, the parts never obtain the perfection of surface of the polished laboratory piece, hence failures can be expected at stresses below say 40 per cent of the ultimate strength.

Corrosion materially affects the endurance limit, especially if hydrogen is liberated to enter the steel. Corrosion fatigue is an important factor in sucker-rod failure in the petroleum industry. The excellent work of Westcott and Bowers of the Gulf Oil Company is a classic in the field of literature of sucker-rod failure by corrosion fatigue. From their work and other observations, the nickel-molybdenum alloy steel S.A.E. 4620 has been selected as possessing the best balance of mechanical and corrosion-resistant properties in keeping with justifiable costs. The alloy was widely used prior to the war. Its use is restricted at the moment but demands for oil should lead to early reinstatement.

The factors favorable to fatigue failure are roughened surfaces, notches, scratches, etc., kinks in rods so that bending stresses are superimposed on other tensile stress.

Factors tending to reduce fatigue failure are smooth surfaces, generous fillets, compressive stresses in the stressed fibers, and low order of stresses.

Alloys are helpful in lowering the tendency to fatigue failure by increasing the tensile strength. This effect of alloys is quite helpful up to a point. Above this point the steel is increasingly notch-sensitive, hence little net gain is made by increasing strength and hardness.

Any manner of introducing compressive stresses in the stressed fibers is helpful where bending is a factor. Shot-blasting is giving remarkable results where properly applied to parts. The blasted parts are in compression. The use of a roller or burnishing tool to upset the surface is widely and profitably used in combating fatigue failures.

Ninety per cent or more of the failures of moving parts is attributed to fatigue. The solutions of the problems presented by this type of failure deserve and are receiving an immense amount of attention.

ALLOYS FOR IMPROVEMENT OF PHYSICAL PROPERTIES

No pronounced trend in the use of alloys to enhance the physical properties of steels has come to the author's attention. However, there has been increased interest in a nickel-chromium manganese steel (12 per cent nickel, 6 per cent manganese, 5 per cent chromium) to form jigs and parts contacting aluminum. The alloy matches in a satisfactory degree the thermal coefficient of expansion of aluminum.

ALLOYS TO RESIST CORROSIVES

The use of alloys to resist corrosive attack and oxidation has been severely curtailed as a result of the shortage in alloying elements caused by the increased demands of war. Attempts are made to use alloys of lower composition than formerly used and to expect from the units a shorter life. This factor is uncertain and not satisfactory in many cases, particularly that of heat-resisting alloys. In other cases substitutions are satisfactory; for example, cracking-coil tubes in petroleum refineries of 18 chromium, 8 nickel alloys are replaced by the 4–6 per cent chrome steel.

Heat-resisting alloys depend largely upon chromium and nickel for their properties. The chromium confers resistance to oxidation and the nickel, by retaining an austenitic structure, causes a better resistance to creep than obtained from the straight chromium alloys.

Petroleum refineries make extensive use of heat-resisting alloys. As the result of economic pressure, the composition of 25–28 chromium, 12 per cent nickel in cast form is the most widely used in this industry.

The 35 per cent nickel, 15 per cent chromium alloy has always been popular in locations where good mechanical proper-

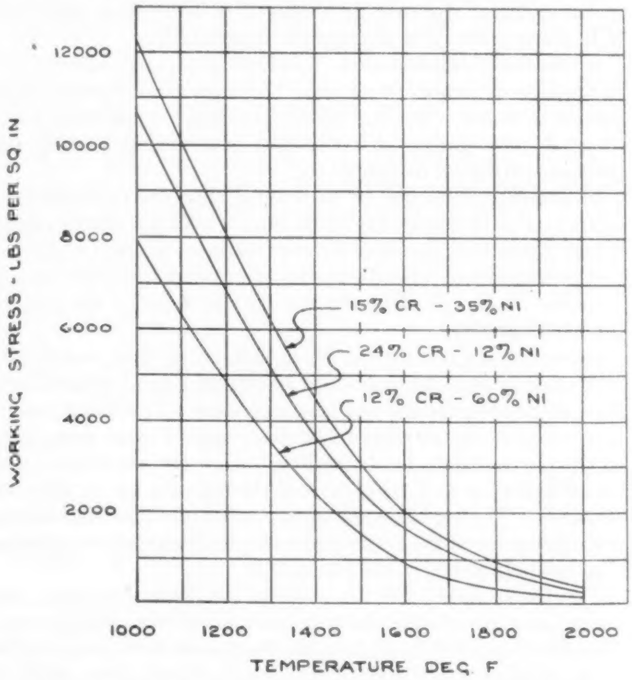

FIG. 1 WORKING STRESSES FOR SOME HEAT-RESISTING ALLOYS
(From catalog F-840 of The Ohio Steel Foundry Company, Springfield, Ohio.)

ties are required at about 1800 F, as in annealing furnaces, etc. "Good mechanical properties" is quite a relative term as can be seen in Fig. 1.

The importance of molybdenum in the 18 per cent chromium, 8 per cent nickel composition has come in for increased acknowledgment. The presence of naphthenic acids in petroleum products and the use of phosphoric acid in refining has stimulated its use. It is also used in connection with the chemicals now produced by refiners.

The use of nickel in sucker rods to offset corrosion embrittlement encountered in many wells has been dwelt on previously in this paper. The importance of nickel-molybdenum steel S.A.E. 4620 as sucker-rod material cannot be over-estimated.

REVIEWS OF BOOKS

And Notes on Books Received in the Engineering Societies Library

Work Methods Manual

Work Methods Manual. By Ralph M. Barnes. John Wiley & Sons, Inc., New York, N. Y., 1944. Cloth, $5^1/_2 \times 8^1/_4$ in., 136 pp., 110 figs., $1.75.

Reviewed by John R. Bangs[1]

THE incentive for simplified job methods is the eventual realization of a better way of life through increased dividends to employer, employee, and consumer. Thus through a better understanding of the principles of efficient work methods, all may profit.

As the author points out, this little book is a guide for supervisors, foremen, and workers on the principles of work organization and motion economy.

Not an exhaustive study on methods, it is in every way a handy guide book for the layman also. From the analyzing of the work, the developing of a better method, the tools used in method improvement, and the extent to which a study should be carried out, it shows how, through the use of job breakdown, process charts, flow diagrams, operation analysis, and motion analysis, simplified job methods can be attained. The material is presented in a treatment devoid of technical phraseology, simple, and concise to the extreme.

Due to the necessity of savings in paper and other war materials the chapters have been very profitably condensed to a point where the text is almost pocket size, with resultant simplification of handling.

Management, supervision, and labor can well profit by its use as a manual in both office and shop. Further, it can be used to advantage in a wide field of endeavor, for experience has shown that revised methods as the result of time and motion study have been, and can be, applied to many "nonmanufacturing" activities including offices, hotels, restaurants, department stores, and mail-order houses. The United States Government, through our Army Service Forces, has been using methods study to great advantage in World War II to speed up and economize the handling of materiel in manufacture, storage, and shipment.

As a stimulant to personnel the free access to this manual is recommended, particularly where labor-management committees function or where suggestion systems are in operation.

For supervisors and foremen, proved examples of savings in time and labor are well illustrated, pointing to the net result of more efficient and speedy production. To management the manual should be welcome through its various demonstrations of proved economy; one example set forth being the moving of radio parts six inches closer to a fixture with a net annual saving of $20,000.

Profusely illustrated, the text carries the reader from subject to subject gradually through Ten Principles of Motion Economy, graphically illustrating the value of each, and climaxing with a simple description of how to put a new method into effect.

The latter is slanted toward the worker as an aid to the presentation of his or her suggestion to supervision, encouraging and giving in simple terms four steps by which he can be assured of success of his idea.

Each chapter is followed by a series of problems with the correct answers, well illustrated, in a special supplement at the end of the book.

Completing the manual is a list of references and acknowledgments which may be used as an aid to a wider study of the subject.

[1] General Manager, Industrial and Personnel Relations, Edward G. Budd Manufacturing Company, Philadelphia, Pa. Mem. A.S.M.E.

Conveyors and Related Equipment

Conveyors and Related Equipment. By Wilbur G. Hudson. John Wiley & Sons, Inc., New York, N. Y., 1944. Cloth, $5^1/_2 \times 8^1/_4$ in., 341 pp., illus., $5.

Reviewed by Matthew W. Potts[2]

THIS book is just what the author claims for it in the preface, namely, a publication to give information regarding the kind of equipment to use to best advantage, and its application and limitations.

It is difficult to prepare a book of this type, because the subject is broad, the types of equipment available under the term "conveyors" are numerous, and each type has many applications.

The book is more than just a general write-up describing the equipment, and goes into technical details regarding capacities, horsepower required, etc. At the same time, it avoids going into extensive discussion regarding engineering design, which is best left to the manufacturers' standards.

The many illustrations and line drawings will be helpful both to the executive and student engineer, and they cover points which are essential to the proper layout, installation, and maintenance of this type of equipment.

While the title speaks of "conveyors and related equipment" it does not cover all forms of conveyors, but deals mostly with those used in the handling of bulk materials, such as screw conveyors, bucket elevators, skip hoists, belt conveyors, drag scraper conveyors, feeder conveyors, pneumatic conveyors, aerial tramways, etc.

The author showed good judgment in keeping the book on the discussion of bulk materials, rather than trying to inject conveyors for handling packaged materials, although there are one or two illustrations which show monorail telphers and electric hoists handling packaged materials. It is felt by the reviewer that it would have been better if this chapter (7) had been omitted from the book.

The related equipment mentioned in the title deals with bins, bunkers, silos, as well as crushers, hammermills, and pulverizers. This also covers vibrating

[2] Materials Handling Consultant, New York, N. Y. Mem. A.S.M.E.

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ENGINEERING Societies Library books may be borrowed by mail by A.S.M.E. members for a small handling charge. The library also prepares bibliographies, maintains search and photostat services, and can provide microfilm copies of any item in its collection. Address inquiries to Harrison W. Craver, Director, Engineering Societies Library, 29 West 39th St., New York, N. Y.

screens and feeders, gates and unloaders, and weighing equipment.

There is also a chapter relating to chains, drives, drive groups, and motors, as well as V-belts, speed reducers, speed changers.

The book is well written, with many helpful, practical hints, and a number of examples of operating cost data.

Because of its composition, the book can serve many readers, whether they are trying to acquire a general knowledge of the subject, or detailed information.

Books Received in Library

AIRCRAFT ANALYTIC GEOMETRY Applied to Engineering, Lofting, and Tooling. By J. J. Apalategui and L. J. Adams. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1944. Linen, $5^1/_2 \times 8^1/_2$ in., 285 pp., diagrams, charts, tables, \$3.00. The methods of plane and solid analytic geometry are applied to the solution of a certain class of problems that arise in the design, lofting, tooling, and engineering of airplanes. There is also a treatment of conic sections as used in design and lofting. The approach is systematic and is based on the principles of plane and solid analytical geometry.

AIRCRAFT MECHANIC'S POCKET MANUAL. By J. A. Ashkouti. Third revised edition. Pitman Publishing Corporation, New York, N. Y., and Chicago, Ill., 1944. Leather, 5×8 in., illus., diagrams, charts, tables, \$1.50. The basic data needed by the aircraft mechanic are provided in this pocketbook, which is intended to meet day-by-day requirements. Standard parts and finishes, structural materials, layout, shop arithmetic; tools, fabricating processes, etc., are discussed.

AMERICAN MACHINISTS' HANDBOOK, Wartime Data Supplement. By F. H. Colvin and F. A. Stanley. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1944. Paper, $4 \times 6^3/_4$ in., 154 pp., diagrams, charts, tables, \$1. Many changes in materials and shop practice have come about as a result of war demands for increased production. This supplement shows changes that have been found advisable in various lines of work, and provides data that have proved helpful. The topics discussed are: materials, screw threads, drilling, grinding-wheel markings, gearing, forging, forming, punching, and welding in aircraft work, inspection and metal-cutting saws.

A.S.T.M. STANDARDS 1943 Supplement including Tentative Standards. Part 1, Metals, 351 pp. Part 2, Nonmetallic Materials—Constructional, 167 pp. Part 3, Nonmetallic Materials—General, 539 pp. American Society for Testing Materials, Philadelphia, Pa., 1944. Cloth, $6 \times 9^1/_4$ in., illus., diagrams, charts, tables, \$3 each part. These volumes bring the 1942 Book of Standards up to date by giving the newly adopted and revised standards and tentative standards. Included are stickers for marking the standards in the 1942 Books that have been superseded.

A.S.T.M. STANDARDS ON RUBBER PRODUCTS (with related information) prepared by A.S. T.M. Committee D-11 on Rubber Products; Methods of Testing, Specifications, February, 1944. American Society for Testing Materials, Philadelphia, Pa. Paper, 6×9 in., 424 pp., illus., diagrams, charts, tables, \$1.75. This compilation brings together the standard and tentative methods of test and specifications pertaining to rubber products. Additions to this issue include specifications for compounds of rubber and synthetic rubber for automotive and aeronautical uses and for insulating electric wire and cable, methods of testing rubber-coated fabrics, asbestos sheet packing, and nonrigid plastics and electrical test methods applicable to rubber products.

BASIC MATHEMATICS FOR ENGINEERS. By P. G. Andres, H. J. Miser, and H. Reingold. John Wiley & Sons, Inc., New York, N. Y., Chapman & Hall, London, England, 1944. Cloth, $5^1/_2 \times 8^1/_2$ in., 726 pp., diagrams, charts, tables, \$4. Presents, in one volume, "the mathematics required for an intelligent pursuit of elementary engineering courses, and serves as preparation for a course in the calculus." It contains those topics from algebra, trigonometry, and analytic geometry needed to meet these objectives. The text is suitable for home study, by students who have had two years of high-school mathematics.

BASIC OPEN HEARTH STEELMAKING, by the Committee on Physical Chemistry of Steelmaking, Iron and Steel Division, A.I.M.E.; edited by the Staff of Alloys of Iron Research, F. T. Sisco, consulting editor; sponsored by the Seeley W. Mudd Memorial Fund. Published by the American Institute of Mining and Metallurgical Engineers, New York, N. Y., 1944. Cloth, $6 \times 9^1/_4$ in., 632 pp., illus., diagrams, charts, tables, \$3 to nonmembers, \$2 to A.I.M.E. members. We have here, for the first time in English, a comprehensive account of the art and science of open-hearth steelmaking. The work is divided into two parts: Practice and Theory. In part one, such topics as basic open-hearth furnaces, refractories, raw materials, slag control, charging and melting, refining, finishing and deoxidation, molds and pouring, segregation and inclusions are discussed by a number of expert steelmakers. In section two, the thermochemistry of the open hearth, the physical chemistry of liquid steel and slags, and the kinetics of the open hearth are similarly treated. The book will be indispensable to everyone engaged in the industry.

CALCULUS REFRESHER FOR TECHNICAL MEN. By A. A. Klaf. McGraw-Hill Book Co., Inc., Whittlesey House Division, New York, N. Y., 1944. Cloth, $5 \times 8^1/_2$ in., 431 pp., diagrams, tables, \$3. The basic concepts and methods of differential and integral calculus are presented by means of questions and answers in this book, which is intended especially for men who have studied the subject before and wish to review it rapidly. Typical examples are worked out and problems provided for the student. A section is devoted to practical applications of calculus to engineering.

DAVISON'S RAYON AND SILK TRADES, including nylon and other synthetic textiles; the Standard Guide, forty-ninth annual pocket edition, 1944. Davison Publishing Co., Ridgwood, N. J., 1944. Cloth, $5 \times 7^1/_2$ in., 414 pp., maps, tables, \$5.50; de luxe office edition, \$7.50. This annual is a directory of manufacturers, importers, factories, and others engaged in the silk industries and the rayon, nylon, and other synthetic-textile trades. The mills are classified by states, with information as to situation, officers, size, and products. Subject indexes are provided.

ENGINEERING MATERIALS, 2 volumes. Vol. 1, The Ferrous Metals, 369 pp., \$7.50 (25s abroad). Vol. 2, Nonferrous and Organic Materials, 479 pp., \$8.50 (30s abroad). By A. W. Judge. Second edition. Pitman Publishing Corporation, New York, N. Y., Sir Isaac Pitman & Sons, London, England, 1943. Cloth, $5^1/_2 \times 9$ in., illus., diagrams, charts, tables. These two volumes form an admirable reference book for engineers, designers, constructors, and others concerned with the selection and application of engineering materials. Volume 1 on ferrous metals presents essential information on their properties, composition, heat-treatments, machining, welding, and other subjects. Volume 2 treats in similar fashion the nonferrous metals and alloys, plastics, rubber, and ceramics. The needs of aircraft and automobile engineers have been kept especially in mind.

FERROUS METALLURGY, two volumes. (Mineral Industries Series.) Vol. 1, Introduction to Ferrous Metallurgy, 484 pp. Vol. 2, Manufacture and Fabrication of Steel, 487 pp. By E. J. Teichert. Second edition. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1944. Cloth, $5^1/_4 \times 8^1/_2$ in., illus., diagrams, charts, maps, tables, \$4 each. The two books are part of a three-volume text based upon a correspondence course given during recent years by the Pennsylvania State College. Volume 1 covers the fundamental chemical and physical background and the manufacture of pig iron, cast iron, and wrought iron; volume 2, the manufacture of steel and its primary fabrication. The books give an excellent, up-to-date account of practice.

FOUNDATIONS OF POTENTIAL THEORY. By O. D. Kellogg, published by The Murray Printing Company, distributed by Frederick Ungar Publishing Company, New York, N. Y., 1944 reprint. Linen, $6 \times 9^1/_2$ in., 384 pp., diagrams, tables, \$6. This is a reprint of the treatise by the late Professor Kellogg which was published in Berlin in 1929 and which was based on his courses at Harvard University. The first quarter of the book treats the subject in a fairly elementary manner, with applications to gravitational theory, electrostatics, magnetostatics, and the flow of heat. The remaining portion is more mathematical in character. The restrictions on the validity of the equations of Gauss and Stokes are examined, and the Dirichlet problem is investigated.

GRAPHICAL SOLUTIONS. By C. O. Mackey. Second edition. John Wiley & Sons, Inc., New York, N. Y.; Chapman & Hall, London, England, 1944. Cloth, $5^1/_2 \times 8^1/_2$ in., 152 pp., charts, tables, \$2.50. Further demand has made necessary the reprinting of this edition, which appeared first in 1940. It provides a course of instruction in the construction and application of curves, diagrams and charts for the graphical and mechanical solution of engineering problems. The treatment is elementary and practical.

GUIDE TO WELDABILITY OF STEELS, published by Welding Research Council, American Welding Society, New York, N. Y., 1944. Paper, 6×9 in., 89 pp., illus., diagrams, charts, tables, \$1. This book presents "a proposed system of determining the effect of welding procedure upon the ductility of the heated zone adjacent to the weld in plain carbon and alloy steels." The system calls for only two tests. With these and the data given in the book, the welding conditions necessary for the preservation of the desired ductility can be predicted.

HANDBOOK ON DESIGNING FOR QUANTITY PRODUCTION, prepared and edited by H. Chase. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1944. Cloth, $5^1/_4 \times 8^1/_2$ in., 517 pp., illus., diagrams, tables, \$5. The design of articles which are to be made in large quantities and which are partly or wholly made of metals or plastics must be predicated upon the use of one or more of the high-production processes: stamping, sand-casting, die-casting, screw machine, die-forging, heading, or plastic molding. In this book, which is for those interested in design of this type, the first part consists of chapters on design for quantity production by these various processes, each written by an authority. In the second part the cost of products by different methods is compared. A large amount of

practical information is provided in convenient form.

ILLUSTRATED TECHNICAL DICTIONARY, edited by M. Newmark. Philosophical Library, New York, N. Y., 1944. Cloth, 6 × 9$^{1}/_{4}$ in., 352 pp., diagrams, tables, $5. This dictionary gives definitions for a wide selection of terms used in the applied sciences and in technology, with special attention to those generally encountered in the curricula of technical and vocational schools. Illustrations are infrequent and add little to the value of the book. The work will be useful to students and mechanics. Many recent expressions are included.

INTERNAL COMBUSTION ENGINES—Analysis and Practice. By B. H. Jennings and E. F. Obert. International Textbook Co., Scranton, Pa., 1944. Cloth, 6 × 9 in., 471 pp., illus., diagrams, charts, tables, $4.50. This text is designed to give students and engineers fundamental and factual knowledge of the broad field of internal-combustion engines. Basic analyses are developed in detail for the many processes that occur in the engine, and illustrative applications are drawn from current literature and manufacturing practice.

MAGNESIUM, Its Production and Use. By E. V. Pannell. Pitman Publishing Corporation, New York, N. Y., and Chicago, Ill., 1944. Cloth, 5$^{1}/_{2}$ × 9 in., 137 pp., illus., diagrams, charts, tables, $4. A practical treatise on magnesium from the engineering and industrial point of view. The methods of producing the metal are described briefly. Most of the book is devoted to the alloys, their heat-treatment, casting and working, corrosion and protective methods, and their industrial application. The book is a useful addition to the literature on magnesium.

MATERIALS AND PROCESSES, edited by J. F. Young. John Wiley & Sons, Inc., New York, N. Y., 1944. Cloth, 5$^{1}/_{2}$ × 8$^{1}/_{2}$ in., 628 pp., illus., diagrams, charts, tables, $5. This book aims to present, in a single volume, a broad study of the materials and manufacturing processes employed by engineering designers, and thus to provide information directly useful in the selection of materials. It is intended for classroom use and also for engineers who wish an over-all picture. The book is based on a course of lectures given in the advanced engineering program of the General Electric Company and incorporates the lectures of many engineers.

MATHEMATICAL AND PHYSICAL PRINCIPLES OF ENGINEERING ANALYSIS. By W. C. Johnson. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1944. Cloth, 5 × 8$^{1}/_{2}$ in., 346 pp., diagrams, charts, tables, $3. This book is the outgrowth of a course given in recent years to students of engineering at Princeton University. Its purpose is to present the physical and mathematical principles and methods of approach that underlie the analysis of many practical engineering problems. The viewpoint is practical and utilitarian. Emphasis is placed upon physical concepts, the use of assumptions, procedures in setting up equations, the use of mathematics as a tool in accurate, quantitative reasoning, and the physical interpretation of mathematical results.

MATHEMATISCHE GRUNDLAGEN DER QUANTENMECHANIK. (Die Grundlehren der Mathematischen Wissenschaften, Bd. 38.) By J. von Neumann. Dover Publications, New York, N. Y., 1943. Cloth, 6 × 9$^{1}/_{2}$ in., 266 pp., diagrams, tables $3.50. Neumann's Mathematical Bases of Quantum Mechanics has long been esteemed by mathematicians and physicists for its thorough logical development and discussion of the subject. The present edition has been produced in America, in response to demand, under license by the Alien Property Custodian. It reproduces the latest German edition, with the addition of a German-English glossary.

MECHANICAL PROPERTIES OF METALS AND ALLOYS. (Circular of the National Bureau of Standards C447.) By J. L. Everhart and others. U. S. Bureau of Standards, Washington, D. C., 1943; for sale by U. S. Government Printing Office, Washington, D. C. Cloth, 8 × 11 in., 481 pp., charts, tables, $1.50. This Circular is a summary of the data available on the strength and related properties, thermal expansion, and thermal and electrical conductivities of ferrous and nonferrous metals and alloys at normal, high, and low temperatures. Included are many metals and alloys which are not ordinarily considered as engineering materials. The data are presented in tables or graphs and the source is given in each case.

MODERN TURBINES. By L. E. Newman, A. Keller, J. M. Lyons, L. B. Wales. Edited by L. E. Newman. John Wiley & Sons, Inc., New York, N. Y.; Chapman & Hall, London, England, 1944. Cloth, 5$^{1}/_{2}$ × 8$^{1}/_{2}$ in., 175 pp., illus., diagrams, charts, tables, $2.50. Information concerning the characteristics of steam turbines and their generators is presented for the use of engineers who are interested in the selection of equipment for a given job, but are not concerned with the details of turbine design and maintenance. The four authors are all connected with the General Electric Company, and the material presented appeared originally in *Power Plant Engineering*.

MODERN WOOD ADHESIVES. By T. D. Perry. Pitman Publishing Corporation, New York, N. Y., and Chicago, Ill., 1944. Linen, 6 × 9$^{1}/_{4}$ in. 208 pp., illus., diagrams, tables, $3. This is an excellent reference book on the properties of glues and resin adhesives, and on their uses and on glue testing. The various glues and resins, the methods of comparing them, glue mixing and spreading equipment, the use of pressure and heat, impregnation, and glue testing are considered from a practical point of view. Each chapter has a useful bibliography.

National Research Council of Canada. ABSTRACTS ON SYNTHETIC RUBBER, Part 1, articles (N.R.C. No. 1136) 362 pp. Part 2, patents (N.R.C. No. 1137) 200 pp. National Research Council of Canada, Ottawa, Canada, June, 1943. Paper, manifold 8$^{1}/_{2}$ × 11 in., tables, $2 each. This publication provides abstracts of over eight hundred articles and over seven hundred patents dealing with synthetic rubber, together with a list of 123 articles and books that are not abstracted. A subject index to the abstracts and an index of patentees are included.

PICTORIAL GUIDE TO MACHINE SHOP PRACTICE. By H. Grisbrook and C. Phillipson. Emerson Books, Inc., New York, N. Y., 1944. Cloth, 5$^{1}/_{2}$ × 8 in., 91 pp., diagrams, $1.50. The basic principles of machine-shop work—fitting, turning, drilling and milling—are presented by means of drawings that show the right and the wrong way of performing each operation. Brief explanations accompany the drawings.

PRACTICAL ANALYTIC GEOMETRY WITH APPLICATIONS TO AIRCRAFT. By R. A. Liming. The Macmillan Company, New York, N. Y., 1944. Linen, 5$^{1}/_{2}$ × 8$^{1}/_{2}$ in., 277 pp., illus., diagrams, charts, tables, $4.50. This book is a comprehensive presentation of the application of analytic geometry to the practical mathematical definition of airplane contours and structure. Part one analyzes applications to two-dimensional space; Part two develops the application of rectangular co-ordinates to three-dimensional space; Part three applies a system of analytic analysis to curves commonly required in the lofting of streamline bodies. While the book deals exclusively with aircraft structures, the principles developed apply equally to such related fields as the automotive and marine industries.

PROTECTIVE AND DECORATIVE COATINGS, vol. 4, prepared by a staff of specialists under the editorship of J. J. Mattiello. John Wiley & Sons, Inc., New York, N. Y.; Chapman & Hall, London, England, 1944. Cloth, 6 × 9$^{1}/_{2}$ in., 419 pp., illus., diagrams, charts, tables, $5. This volume of this treatise on coatings is devoted to studies of such subjects as wetting and grinding, the properties of the manufactured product, such as color, consistency and hiding, the adhesion, permeability, and structure of the dried film, the uses of microscopy in the paint and varnish industry, and the applications of high-vacuum technology. The chapters have useful bibliographies.

PUNCHES AND DIES, Layout, Construction and Use Including Wartime Data Supplement. By F. A. Stanley. Third edition. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1943. Cloth, 6 × 9 in., 509 pp., illus., diagrams, tables, $4. The text of the second (1936) edition of this well-known manual on the layout, construction, and use of punches and dies is republished with a thirty-three page supplement describing late developments in press tools and methods in connection with war work such as the use of contour machines on die work, the Guerin process cast dies, fabricated press tools, and other novelties.

RAILWAY FUEL AND TRAVELING ENGINEERS' ASSOCIATION, Seventh Annual Proceedings, 1943. Railway Fuel and Traveling Engineers' Association, Chicago, Ill. Cloth, 6 × 9$^{1}/_{4}$ in., 206 pp., illus., diagrams, charts, tables, $3. The Proceedings contain the reports of the officers and of various committees on gas-turbine locomotives, firing practice, Diesel locomotives, coal firing, and the utilization of motive power with discussions. There are also papers on efficiency and economy in steam-locomotive operation and on fast-freight braking.

STEAM LOCOMOTIVE, Its Theory, Operation, and Economics Including Comparisons With Diesel-Electric Locomotives. By R. P. Johnson. Second edition, revised and enlarged. Simmons-Boardman Publishing Corporation, New York, N. Y., 1944. Cloth, 6 × 9$^{1}/_{2}$ in., 564 pp., illus., diagrams, charts, tables, $5. This book, by the chief engineer of the Baldwin Locomotive Works, presents the fundamentals of steam-locomotive design and operation. The information is presented concisely, in practical form, with many tables and diagrams. New chapters on steam utilization, the distribution of locomotive weight, and braking have been added to this edition, and the original text has been revised.

SUPERCHARGERS FOR AVIATION. By S. A. Moss. Second edition. National Aeronautics Council, New York, N. Y., 1944. Cloth, 5$^{1}/_{2}$ × 8$^{1}/_{2}$ in., 103 pp., illus., diagrams, charts, $1. The purpose of this book is to satisfy those "who are interested in superchargers in a general way, and want to know their how and why, and their historial background." It presents, revised and extended, material published in *Aeronautics*, three years ago. No mathematics is used in the account. The author has been prominently connected with supercharger and gas-turbine development and writes with authority.

SYMPOSIUM ON MALLEABLE IRON MELTING, Reprint 43-37, published by American Foundrymen's Association, Chicago, Ill. Paper, 6 × 9 in., 243 pp., illus., diagrams, charts, tables, $2 to members; $3 to nonmembers. The fifteen papers here collected deal with all

phases of malleable melting practice. Some of the subjects discussed are the use of open-hearth furnaces, duplexing in cupolas and electric furnaces or air furnaces, Brackelsburg furnaces, and firing with pulverized coal and with oil. The papers were presented at a symposium at the 1943 Foundry Conference in St. Louis.

SYMPOSIUM ON THE SIGNIFICANCE OF THE HARDNESS TEST OF METALS IN RELATION TO DESIGN, presented at the Forty-Sixth Annual Meeting, the American Society for Testing Materials, Pittsburgh, Pa., June 29, 1943. Published by the American Society for Testing Materials, Philadelphia, Pa., 1943. Paper, 6 × 9 in., 60 pp., reprint from Proceedings, illus., diagrams, charts, tables, $0.75. This pamphlet contains a series of papers presented at the 1943 annual meeting of the Society and previously published in its Proceedings. The various types of hardness tests, the indentation hardness test and the fundamentals of hardness testing are discussed.

TECHNOLOGY AND LIVELIHOOD, an Inquiry into the Changing Technological Basis for Production as Affecting Employment and Living Standards. By M. L. Fleddérus and M. van Kleeck. Russell Sage Foundation, New York, N. Y., 1944. Paper, 6 × 9 in., 237 pp., charts, tables, $1.25. This report, prepared for the Russell Sage Foundation, is a study of the effect of recent changes in the productive capacity of our basic industries upon opportunities for employment and upon living standards. The information accessible in government publications has been assembled and summarized so as to be understood by those without experience in production or training in technology.

TIME STUDY ENGINEERING. By W. H. Schutt. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1943. Cloth, 6 × 9 in., 426 pp., illus., diagrams, $5. Every detailed phase of time study is covered on the basis of specific machine studies and in a simplified form understandable by those unfamiliar with shop production methods. Shop production methods, machinery, and tools are completely explained as well as the step-by-step study that should be made of particular operations. New, simplified explanations of speeds and feeds are given, and also detailed analysis for determining "line tasks" and controlling manpower.

TESTING OF ENGINEERING MATERIALS. By C. W. Muhlenbruch. D. Van Nostrand Co., Inc., New York, N. Y., 1944. Cloth, $6^1/_2$ × $9^1/_2$ in., 200 pp., illus., diagrams, charts, tables, $2.75. This book is intended as a text for a one-semester laboratory course for engineering students. It aims to give the student, through comprehensive testing of a variety of materials and a careful analysis of the results of the tests, a clear picture of those properties that can be most readily illustrated in the testing laboratory and to acquire an understanding of the physical properties of the common engineering materials and of the possibilities and limitations of the latter.

THERMAL TECHNICS OF STEAM BOILERS. By J. Webster. Emmott & Co., Ltd., Manchester, and London, England, 1943. Paper, 5 × $7^1/_4$ in., 66 pp., diagrams, tables, charts, 1s 6d. This pamphlet presents concisely information needed by boiler engineers in studying problems connected with such subjects as boiler limitations, rates of heat-transfer, the estimation of efficiency, methods of determining the temperatures of gas and air, and steam and water, the proportioning of heat-transmitting parts, the relationship of water content to fluctuating load, thermal storage, and heat transmission.

TOOLS STEELS. By J. P. Gill, R. S. Rose, G. A. Roberts, H. G. Johnstin, and R. B. George. American Society for Metals, Cleveland, Ohio, 1944. Cloth, 6 × $9^1/_4$ in., 577 pp., illus., diagrams, charts, tables, $6. The aim in this book is to set forth concisely the existing theoretical and practical information on the types of tool steel that are commonly used. A description of the manufacture of tool steel is followed by chapters on testing, the principles of heat-treatment, and the effect of alloying elements on the steel. Succeeding chapters review in detail the various classes of tool steels, presenting the available data about their properties, treatment, and uses. The work is intended for users of tool steel. The authors are members of the metallurgical staff of the Vanadium-Alloys Steel Company.

WORK METHODS MANUAL. By R. M. Barnes. John Wiley & Sons, Inc., New York, N. Y.; Chapman & Hall, London, England, 1944. Cloth, $5^1/_2$ × $8^1/_2$ in., 136 pp., illus., diagrams, charts, tables, $1.75. While the steps to be followed in doing given work, the selection of tools and equipment, and the instruction of the worker are usually the function of staff engineers in plants on mass production, most work is not repetitive, and the worker may do several different jobs in a day or week. In these cases the supervisor usually must plan the job, select the tools, and instruct the worker. This book is intended to give supervisors and foremen a working knowledge of the principles of work organization and motion economy which will enable him to plan fo economy and efficiency.

A.S.M.E. BOILER CODE

Interpretations

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Anyone desiring information on the application of the Code may communicate with the Committee Secretary, 29 West 39th St., New York 18, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are then sent by the Secretary of the Committee to all the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and is passed upon at a regular meeting.

This interpretation is later submitted to the Council of The American Society of Mechanical Engineers for approval after which it is issued to the inquirer and published in MECHANICAL ENGINEERING.

Following is a record of the interpretations of this Committee formulated at the meeting of May 26, 1944, and approved by the A.S.M.E. Council on June 20, 1944.

CASE NO. 1012

(Special Ruling)

Inquiry: May nickel-copper alloy Monel metal bars complying with A.S.T.M. Specification B164-41T (proposed A.S.M.E. Specification SB-164) be used for threaded rigid staybolts in power boilers?

Reply: It is the opinion of the Committee that the use of such material in staybolts will comply with the intent of the Code provided the material is annealed and the maximum allowable stress does not exceed 9500 psi, in place of the value given in item *(a)* of Table P-9.

Proposed Revisions and Addenda to Boiler Construction Code

IT IS the policy of the Boiler Code Committee to receive and consider as promptly as possible any desired revisions of the rules and its codes. Any suggestions for revisions or modifications that are approved by the Committee will be recommended for addenda to the code, to be included later in the proper place.

The following proposed revisions have been approved for publication as proposed addenda to the code. They are published below with the corresponding paragraph number to identify their location in the various sections of the code and are submitted for criticism and approval from anyone interested therein.

It is to be noted that a proposed revision of the code should not be considered final until formally adopted by the Council of the Society and issued as pink-colored addenda sheets. Added words are printed in SMALL CAPITALS; words to be deleted are enclosed in brackets [ ]. Communications should be addressed to the Secretary of the Boiler Code Committee, 29 West 39th St., New York 18, N. Y., in order that they may be presented to the Committee for consideration.

Par. U-201 *(b)*. Revise the form of this paragraph as it appears in the May, 1944, issue of MECHANICAL ENGINEERING, to read:

U-201 *(b)*. A welded joint efficiency of [85] 80 per cent may be used.

Table P-2. There is a typographical error in note 4 of this table which appears on page 9 of the 1943 edition of the A.S.M.E. Power Boiler Code. The reference to Specification SA-226 was inadvertently included and should be deleted.

A.S.M.E. NEWS

And Notes on Other Engineering Activities

1500 Attend A.S.M.E. 1944 Semi-Annual Meeting at Pittsburgh, June 19-22

Crowded Program of Technical Papers Includes Addresses and Inspection Trips

ONE of the most successful and comprehensive semi-annual meetings of The American Society of Mechanical Engineers was held at the William Penn Hotel in Pittsburgh, Pa., June 19–22, with an attendance of 1500. All four days were crowded with discussions, addresses, papers, and inspection trips of vital interest to everyone in attendance. As a matter of fact, in the welter of interesting topics one of the chief sources of complaint was an individual's inability to attend two sessions at the same time.

Four major luncheons were all strongly attended and the semi-annual dinner was a huge success. Ample accommodations were available for the numerous committee meetings that were necessary to transact the matters of business affecting the management and conduct of the affairs of the Society. In spite of war conditions, a different inspection trip was arranged for each day of the meeting, and the trips ranged in interest from steelmaking through shipbuilding and drop-forging to the fascinating subject of ocean ship construction on rivers far inland. Practically all of the plants visited acted as generous hosts to those in attendance.

The program for women visitors was especially attractive and entertaining and many were the compliments paid to the local committee that sponsored the arrangements for the women. Strictly Society affairs were discussed at the meetings of the Council on Sunday and Monday (see pages 554 and 555 of this issue).

The Nominating Committee held its meeting on Tuesday, June 20, while the semi-annual business meeting was held on Monday.

Discussion at Business Meeting

Discussion at the business meeting revolved around the question of charging members of the Society a registration fee for attendance at national meetings to provide a fund for entertainment and other expenses. Opinion was in favor of not changing the present practice, which is to charge a registration fee for nonmembers but none for members.

There was also discussion of the policy of holding national meetings in wartime when transportation facilities are crowded. The subject had been discussed by the Council, it was announced, and decision on holding the Fall Meeting at Cincinnati was to be taken after a thorough study.

Management Sessions and Luncheon

The public sessions of the semi-annual meeting commenced with three concurrent sessions on aviation, management, and metals on Monday morning. The Management Division with its program stressing quality control presented two papers of timely interest, by authors well known to be experts in this field, J. M. Juran and M. J. Manuele, respectively.

The two papers were intended to brush away the fog which heretofore has covered this tool of scientific management. Past attempts to present quality control to an audience have involved a maze of statistics and data, hence, creating many uncertainties. The approach used by Mr. Juran and Mr. Manuele eliminated almost entirely these methods with the consequent result that the large audience found itself being sold the values of quality control in the same manner that will be required to sell it to the personnel of an industry.

Both authors used words of one syllable and illustrations of only two dimensions in the presentation of their ideas. Mr. Juran's paper, which appears in this issue, tended to follow the pattern of technical-meeting presentation. Mr. Manuele ably presented the subject of quality-control techniques through the use of lantern slides developed by himself for training the personnel of his organization in this work.

Following the morning sessions, the Management Division held its luncheon which included an address of welcome from the chairman of the Pittsburgh Section of theA.S.M.E., Lester E. F. Wahrenburg. After the response by President Robert M. Gates, the chairman, Webster N. Jones, introduced the speaker Frank D. Newbury, vice-president, Westinghouse Electric & Manufacturing Company The speaker's address was a timely plea for the

Westinghouse Photo

CHATTING BETWEEN SESSIONS AT THE SUMMER MEETING OF THE A.S.M.E. IN PITTSBURGH, PA., ARE R. E. PETERSON AND C. M. LAFOON OF THE WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY, T. E. PURCELL, DUQUESNE LIGHT COMPANY, AND C. C. FRANCK, WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY

(Messrs. Peterson and Purcell served on the Technical Events Committee. Mr. Lafoon spoke on "Power Trains," and Mr. Franck presented a paper on the steam turbine designer's reliance on research and experimental laboratories.)

early repeal of rigid government price controls in the postwar period to permit the adjustment of military production to the products of a peacetime economy. The implications presented in his analysis of the subject were very provocative of thought. Mr. Newbury's address will be found on pages 501-504 of this issue.

The three Monday afternoon sessions stressed aviation, management, and lubrication. At the Management Session, three papers on methods improvement presented the points of view of management, labor, and the consultant. The three addresses were published in MECHANICAL ENGINEERING, July, 1944, pages 463-468.

The postwar aspect of the economic welfare was considered by J. K. Londen, of the Armstrong Cork Company, who spoke from the viewpoint of management. The harnessing of the colossal energies and producing ability of American industry in a postwar world was considered possible if a higher standard of living could be developed in the world and thus create an outlet for the goods produced.

Clinton S. Golden, assistant to the president of the United Steel Workers of America, presented a paper on the reactions of people,—individuals—toward economic security in the postwar scheme of affairs. America's astounding war production was accomplished by the workers' ability to hold and satisfactorily fill their assignments. Such ability and security must be assured in the era of peace.

The paper by H. B. Maynard, who presented the viewpoint of the consultant, contained a number of remarks that should stimulate thought. His statements regarding the general public's inconsistent attitude toward improving the methods of getting things done were very timely. The public welcomes improvements in methods if they result in favorable consumer prices. On the other hand it aquiesces in the "ban on the use of time studies in Government installation repassed year after year by its chosen government representatives with each new appropriations bill." The ranks of labor also lack understanding of the aims and results of this tool of management. Too often it is associated with the "speed up" or "stretch out" program so dear to the hearts of a certain class of "efficiency experts" of a quarter century ago. If tangible advances are to be made, the intelligent co-operation of management, labor, and government must be attained. These were only a few of the points raised by this paper.

In the evening a session was held on the subject of applied mechanics in metals engineering and dealt with the development of new designs of test machines for carrying out creep and creep-rupture investigations. Also a paper was presented on the various methods of making joints in aluminum. All of these subjects were of interest.

Industrial Furnaces Discussed

Another session that created considerable comment was the panel discussion on recent advances in the design of industrial furnaces. It was sponsored by the Heat Transfer Division. An impressive panel of 22 speakers all skilled in their respective fields presented a comprehensive picture of the subject. At this session there were close to 300 in attendance, of whom about 33 per cent were keymen associated with the major metal industries in the Pittsburgh area. At the close of the panel discussion, H. C. Hottel, of the Massachusetts Institute of Technology, who acted as chairman, presented a summary which will be published in a later issue.

Tuesday morning's sessions covered aviation fuels and production engineering. At the latter session Manuel Tama discussed the induction furnace as applied in the aluminum foundry. The author explained the general features and characteristics of the induction furnace and described the practice of the melting of aluminum and the advantages gained through the use of the induction furnace designed for this application.

Selection of Fuels

In the fuels sessions, E. C. Payne, of the Consolidated Coal Co., New York, N. Y., discussed the advisability of investigating all available fuels and their characteristics, and of basing the design of power plants on the results. Mr. Payne's paper will be found in this issue.

The selection of a coal for a power plant must be considered in the light of long availability, with due emphasis being placed on possible conscription of highly desirable specialty fuels for restricted uses during emergencies. In addition the geographical location of industrial communities in the United States is often determined by the proximity of basic raw material and low-cost transportation. Thus it is important to consider competitive fuels in the initial analysis.

Colonel Weaver Describes Conditions in Southwest Pacific

The gathering at the luncheon held on Tuesday was addressed by Col. William A. Weaver on the subject of "Army Ordnance in the Southwest Pacific." It was a talk vibrant with the sincerity of personal experience and portrayed vividly the terrific conditions under which our armed forces are carrying on in the Southwest Pacific. Some of the high lights of the speaker's comments were well worth repetition.

There is nothing worse than being eaten alive by jungle pests in a slit trench. "Mosquitos," he said, "are sometimes worse than Japs." The text of Colonel Weaver's address will be found on pages 505-508 of this issue.

In the afternoon concurrent sessions were held on the uses of new metals in modern railroad development, on heat transfer, and on production engineering.

Discuss Car Materials

The subject of modern structural materials for railway cars was discussed at a joint session of the Railroad Division and the Metals Engineering Division on Tuesday afternoon.

Three formal papers on the subject of the meeting were presented in sequence and followed by a general discussion. These papers included "The Development and Trend in Modern Structural Materials for Railroad Rolling Stock," by S. H. Badgett, mechanical engineer, Pressed Steel Car Company, Inc., Pittsburgh, Pa.; "Structural Material for Railroads," by H. W. Gillett and S. L. Hoyt, Battelle Memorial Institute, Columbus, Ohio; and "Use of Aluminum in Railway Construction," by A. H. Woollen, railway division engineer, Aluminum Company of America, Pittsburgh, Pa. Mr. Badgett's paper analzyed the characteristics of various types of steel, magnesium, and aluminum as used in railway rolling stock. He emphasized the improvements in steelmaking practice and said that when heat-treatment does not give the desired physical properties, the use of alloys at somewhat increased cost must be resorted to. The second paper, read by Dr. Hoyt, also discussed the use of modern materials in railway equipment including cars and locomotives, and stressed the important part which recent metallurgical developments have played in securing the most efficient use of these materials. Mr. Woollen confined his remarks to the use of light alloys, primarily aluminum in railroad rolling stock in which it has passed the experimental stage. He said that fabricating methods have now been largely standardized and present no particular difficulties to equipment builders.

In the discussion which followed presentation of these three papers, several members commented on the rigid deflection limit in present A.A.R. passenger-car specifications which they said present an unnecessary hardship to car designers who want to use either aluminum alloys or stainless steel as the principal structural material. It was recommended that individual car builders specialize in the respective types of construction for which they have the necessary shop equipment and perfected fabricating methods. In attaining minimum car weights, it was pointed out that the present relatively heavy weight of most car specialties constitutes a definite challenge to the manufacturers of this equipment.

Following the general discussion of materials utilized in building railway equipment, a paper, "Draft Gear Action in Train Service," was presented by title, the author being O. R. Wikander, mechanical engineer, ring spring department, Edgewater Steel Co., Pittsburgh, Pa. This paper consists primarily of a mathematical analysis of the characteristics of draft gears, based upon a study of the mechanics of an elastic bar subjected to external forces corresponding to those acting on trains under various conditions of service. Numerical examples are given, showing the application of equations given in the table to assumed test trains.

The evening meetings covered fuels and the use of wood in the aircraft industry. At the latter session J. A. Sporitic discussed the various properties of wood that affect its use in airplane design. The advantage of the "sandwich" type of construction in aircraft design was indicated in the experience gained with this method of fabrication in planes used in actual military combat.

Extrusion and Corrosion

Two papers were presented and discussed at the Aviation-Metals Engineering Session. The first paper, by K. F. Thornton, Aluminum Company of America, was on the subject of "Stepped Extrusions." Mr. Thornton discussed the application of these extrusions to spar caps employed in some aircraft designs, and mentioned that in some instances such extrusions provide economy in material cost and machine-hours to finish the part and also make available extrusions of larger spar cross section with existing equipment. He then briefly explained the process, tolerances, properties, and other characteristics, and concluded with comments concerning future development. In the discussion which followed, continuously variable or multiply-stepped extrusion and die design were the more important points covered.

The second paper, "The Effect of Combined

High Temperature and High Humidity on the Corrosion of Samples of Various Metals," by B. W. Jones and W. L. Maucher, General Electric Company, was presented by Mr. Jones. It covered qualitative corrosion tests of four groups of eighteen different selected metal specimens under indoor and outdoor exposure in an oil refinery along the Gulf Coast. General conclusions were given covering choice of material and finish for electrical equipment for service under these conditions. In the discussion, it was emphasized that the data were not intended for drawing final conclusions for other equipment or service.

Novel Power Plants Described

On Wednesday morning Aviation, Power, Heat Transfer, and Education and Training sessions were conducted.

The paper prepared by Lester E. F. Wahrenburg and H. H. Van Kennan described a novel departure in the design of power plants. The aim as described by the authors was to develop equipment of relatively small output, say, 500 kilowatts, that was extremely mobile. Such units can be readily moved into locations to meet the critical demands for power necessitated either by the destruction sustained from aerial bombing or from the enemy's "scorched earth" policy. The equipment of such an installation is shipped in 23 packages and may be transported by rail, water, or motor transport, to any practical location. The assembly of the whole plant can be completed in 36 hours.

Following this paper there was an informal discussion, illustrated with slides, on the Westinghouse power trains. C. M. Lafoon, of the Westinghouse Electric and Manufacturing Company, gave a general description of the 5000-kw and 1000-kw power trains. Otto de Lorenzi, of Combustion Engineering Co., Inc., described in detail the boilers designed for the 5000-kw train, while F. G. Ely, of The Babcock and Wilcox Company, furnished details of the boiler for the 1000-kw train. These boilers, because of space and weight limitations, require high heat releases and use a locomotive type of stoker and furnace to obtain these releases.

Visual Aids

A session of great interest dealt with the use of visual aids in education and accelerated training. These new devices have been adopted rapidly during these years of war demands, and as experience is gained many modifications in the technique have been necessary.

Visual aid, a relatively new device, still deals with broad generalities as compared with other engineering problems. Making films on engineering is in itself an engineering problem, involving a detailed analysis of the process, co-ordination with other methods of instruction, and a different type of approach and thought.

Calvin W. Rice Lecture

At the Wednesday luncheon the speaker was K. Y. Chen of the China Defense Supplies, Inc. In his Calvin W. Rice Memorial Lecture he discussed "What Postwar China Hopes for From U. S. Engineers." The address conveyed a comprehensive picture of the stupendous task faced by China in the rehabilitation of that country during the postwar period. In such planning the engineer is the key figure and the speaker's theme was a plea for the engineers of the United States to co-operate and guide such a vast undertaking. Mr. Chen's address will be found in MECHANICAL ENGINEERING for July, pages 456–458.

Postwar Problems in Training

After Mr. Chen's address on one phase of postwar reconstruction, it was fitting that one whole session should be devoted to postwar training. Dr. J. C. Wright, of the U. S. Department of Education, in his interesting talk stressed the potential problem of vocational training for the millions of individuals returning from the armed forces and changing from the factories engaged in the industries supplying the materials of war to peacetime production. Consideration must be given to the huge group of untrained youth, most of whom have never held a wage-earning position, that will return when the conflict ends.

Many of these individuals will be from two to five years older in years but perhaps five to ten years older in thought and maturity and with a keen desire to establish themselves as heads of families. To do this, these men will need adequate wage-earning capacities. The postwar needs of business, industry, agriculture, and the home are uncertain and complex and the co-operation of management, labor, and educational institutions is essential.

Lt. Col. C. B. Rhoads, of the Rehabilitation Division of the United States Marine Corps, outlined in an interesting manner the aims and plans of the Marine Corps in dealing with the placing of discharged men in civilian life. The adjustment from military to civilian life is severe and the Marine Corps has recognized this and has taken steps to alleviate this dislocation.

Sikorsky Honored

Wednesday evening the semi-annual dinner was held at the William Penn Hotel. Igor I. Sikorsky was the guest of honor and was the recipient of the Worcester Reed Warner Medal, presented by President Gates of the A.S.M.E., who acted as toastmaster. Following the presentation Mr. Sikorsky gave an excellent address, illustrated by movies on "Direct-Lift Aircraft." The text on Mr. Sikorsky's address will be found in this issue, pages 509-510.

Reliance on Research

On Thursday morning the Power Division sponsored a session at which C. C. Franck, of the Westinghouse Electric and Manufacturing Company, discussed the steam-turbine designer's reliance on research and experimental laboratories.

Mr. Franck said that much of the improvement in steam turbines has resulted from the research of metallurgists. Listed among the improvements in turbines were their ability to resist temperatures as high as 950 F, their ability to produce greater power than previously, the virtual elimination of blade vibration, and the substantial reduction in blade erosion. The use of a 1,000,000-volt X-ray machine to discover flaws in turbine castings, the experimental turbine and equipment used in the research program in connection with blade design to withstand the severe shocks imposed on them when operating at high peripheral speed at high temperature, and the manner in which aerodynamic principles are used in determining the shape of turbine blades were discussed by Mr. Franck.

The impetus given to the development of synthetic rubber and plastics by the war was apparent in the session on materials. E. G. Kimmich, of the Goodyear Tire and Rubber Company, indicated that with the exception of engine and instrument mounts every requirement for mechanical rubber goods in modern aircraft has been met by synthetic rubber.

In the aviation field R. J. S. Pigott discussed the use of rotary pumps in such service. He stated that some of the advantages of the rotary unit are that it can handle liquids containing considerable quantities of gas and vapor quite satisfactorily, while the reciprocating pump has been unsatisfactory and the centrifugal pump fails completely under such conditions of service.

The subject of material handling was the basis of an interesting paper prepared by Randolph W. Mallick, of the Westinghouse Electric and Manufacturing Company, who indicated that in the United States alone the handling of materials constitutes approximately 22 per cent of the labor cost and represents about $4,000,000,000 annual pay roll.

Concluding Luncheon

The final luncheon of the meeting held on Thursday was addressed by Dr. Webster N. Jones, Director of the College of Engineering, Carnegie Institute of Technology. His subject, "Days to Come," dealt with the necessity of a broadened sphere of activity for the engineer. It was a philosophical address based on wide experience as an educator dealing with young engineers, and it dealt with some of the implications to be discerned in the events brought about by the war.

[The foregoing account was prepared by H. F. Hebley, Pittsburgh Coal Company, based in part on brief reports by others of some of the numerous sessions. Because of the extensive nature of the program, it was not possible to mention every paper or all of the sessions.—EDITOR.]

Committees Responsible for Meeting

The 1944 A.S.M.E. Semi-Annual Meeting was conducted under the general direction of the Standing Committee on Meetings and Program, L. K. Sillcox, chairman, and the professional divisions and committees of the Society.

The Pittsburgh Committee was under the general chairmanship of R. J. S. Pigott, with Lester E. F. Wahrenburg as vice-chairman and E. W. Jacobson as secretary. Subcommittees constituting the general committee were:

Finance: H. E. Haller, Sr., chairman; F. Denig, J. M. Hopwood, T. D. Jolly, C. W. Bennett, and F. B. Bell.

Technical Events: B. C. McFadden, chairman; John C. Hoar, T. E. Purcell, R. E. Peterson, W. Trinks, R. E. Hall, and R. G. Sturm.

Hotels: H. B. Mann, chairman; T. A. Peebles, and K. F. Treschow.

Entertainment: B. M. Herr, chairman; T. J. Barry, R. J. Weber, Howard Moss, Harvey Garrett, Wm. Whigham, and Earl Moore.

Registration: W. D. Canan, chairman; L. N. Scharnberg, H. S. Coleman, T. O. Schrader, A. Butcher, W. B. McQuiston, T. G. Beckwith, Sumner B. Ely, John S. Gibson, Van A. Reed, Jr., Henry G. Klein, D. C. Saylor, Christian Wilson, Jr., and Richard C. Wilson.

Publicity: H. F. Hebley, chairman; G. E. Dignan, H. Henderson, M. A. Mayers, and J. R. Tanner.

Plant Trips: M. R. McConnell, chairman; J. R. Aikins, W. N. Flanagan, Wm. Koenig, R. W. Marvin, C. W. Rice, and F. C. Seeger.

Actions of the A.S.M.E Council

At Meetings in Pittsburgh, Pa., June 18 and 19

MEETINGS of the Council of The American Society of Mechanical Engineers were held in the office of the Engineers Society of Western Pennsylvania and in the Adonis Room, Hotel William Penn, Pittsburgh, Pa., on the afternoon and evening of June 18 and the morning of June 19, coincident with the 1944 Semi-Annual Meeting of the Society.

President R. M. Gates presided. Present at all sessions were: Alexander G. Christie, Harold V. Coes, and William A. Hanley, past-presidents; Joseph W. Eshelman, D. W. R. Morgan, Jonathan A. Noyes, Walter J. Wohlenberg, vice-presidents; Alton C. Chick, William G. Christy, Thomas S. McEwan, Roscoe W. Morton, James M. Robert, A. R. Stevenson, Jr., and Albert E. White, managers; S. R. Beitler (Local Sections) and W. M. Sheehan (Professional Divisions); T. G. Beckwith and R. L. Wells, Junior observers; and C. E. Davies, secretary.

Present at the sessions on Sunday only were: R. F. Gagg and F. L. Wilkinson, Jr., vice-presidents; George L. Knight (Finance) and A. R. Mumford (Local Sections); and Ernest Hartford, executive assistant secretary, and John E. Younger, secretary, Aviation Division.

Present at the Monday session only were: J. Calvin Brown, manager; A. C. Harper (Education and Training for the Industries), Stephen D. Moxley (Local Sections), Donald S. Walker (Meetings and Program), H. L. Crain and A. M. Ormond (Nominating), and R. J. S. Pigott (Pittsburgh Meeting); H. H. Snelling, guest; and R. L. Sackett, assistant to the Secretary.

1944–1945 Budget

The estimate of income and budget of expenditures for 1944–1945 (see page 555 of this issue) were approved.

Visits to Sections and Branches

Members of the Council reported on visits, since December, to the sections and student branches in their respective areas.

Proposed Constitutional Change

Upon recommendation of the Committee on Constitution and By-Laws, approval was voted of deletion of the word "local" from "local section," and to submit this amendment to the membership for letter ballot when other constitutional amendments are proposed.

1945 Meetings

Approval was voted of holding the 1945 Spring Meeting in Boston, Mass., in April, and the 1945 Semi-Annual Meeting in Chicago, in June.

Status of Engineer

A progress report of the Committee on Status of the Engineer was noted.

Society Organization

G. L. Knight, chairman, Committee on Society Organization Structure, submitted an informal report. The final report of this committee, after review by the Executive Committee, is to be released to the Group Delegates' Conferences and for publication in MECHANICAL ENGINEERING.

E.C.P.D.

At the request of the Engineers' Council for Professional Development the A.S.M.E. Council authorized E.C.P.D. to undertake a survey of technical institutes under the direction of the E.C.P.D. Committee on Engineering Schools.

Ceremony at British Embassy

President Gates reported on the ceremony at the British Embassy, Washington, D. C., at the invitation of the Earl of Halifax, British Ambassador, at which a portrait of James Watt was presented to the A.S.M.E. by The Institution of Mechanical Engineers, and certificates of honorary membership were exchanged. President Gates accepted a certificate of honorary membership in I.M.E. to be transmitted to Orville Wright and presented a certificate of honorary membership in A.S.M.E. that will be delivered to Harry Ricardo, president I.M.E. Harvey N. Davis, past-president, A.S.M.E., received a certificate of honorary membership in I.M.E. The ceremony was reported in MECHANICAL ENGINEERING, July, 1944, page 492.

Chinese Institute of Engineers

President Gates reported a communication from the president of the Chinese Institute of Engineers, Tseng Yang-Fu, which was delivered personally by Paul B. Eaton, former member of the Council, who had just returned from a mission to China and who had been appointed honorary vice-president to represent the Society during his stay there. The communication expressed thanks for the courtesies of the Society extended through Professor Eaton, and stated that in order "to strengthen the co-operation between this Institute and the engineering societies in the States a committee on Sino-American technical co-operation is under organization in this Institute."

The Institute presented to the Society a silk panel on which are four Chinese characters which may be interpreted: "Spiritually and Materially We Keep Constantly in Good Contact."

The Council authorized the President to respond to the communication, to express pleasure at the opportunity for co-operation, to pledge the support of the Society, and to thank the Institute for its gift.

The Council also expressed its grateful appreciation to Professor Eaton for his services to the Society during his sojourn in China.

Standardization of Gas Properties

As a result of a communication from A. G. Christie, the Council authorized the President to appoint a committee to prepare a program for the standardization of the properties of gaseous mixtures for gas turbines.

Vote of Appreciation

The Council voted to express to the Engineers Society of Western Pennsylvania "its deep gratitude and sincere appreciation for the hospitality and many courtesies extended to the Council and to A.S.M.E. members during the Semi-Annual Meeting in Pittsburgh."

Actions of A.S.M.E. Executive Committee

At Meeting in Pittsburgh, Pa., June 18

THE Executive Committee of the Council of The American Society of Mechanical Engineers met in the office of the Engineers Society of Western Pennsylvania, Hotel William Penn, Pittsburgh, Pa., on the morning of June 18, coincident with the 1944 Semi-Annual Meeting of the Society. There were present: R. M. Gates, chairman, A. C. Chick, D. W. R. Morgan, A. R. Stevenson, Jr., of the Committee; G. L. Knight (Finance), S. R. Beitler and A. R. Mumford (Local Sections), W. M. Sheehan (Professional Division); C. E. Davies, secretary, and Ernest Hartford, executive assistant secretary. Other members of the Council present were W. G. Christy, R. F. Gagg, T. S. McEwan, Roscoe W. Morton, J. A. Noyes, and F. L. Wilkinson, Jr.

Dues of Members in Canada

Loss in currency exchange will be absorbed by the Society in the cases of members in Canada who pay dues on or before Dec. 1, 1944, and of student members and new members in Canada, including initiation fees, during 1944–1945.

Resignation of Joseph L. Kopf

Approval was voted of the presentation to Joseph L. Kopf, for several years a member of the Finance Committee, of a certificate expressing "deep appreciation for the splendid services rendered by him as a member and as a chairman of the Finance Committee."

Certificate of Appreciation

A revised form of a "certificate of appreciation," for use by standing committees and sections for the recognition of substantial services to the Society, was approved. In all cases these committees will request permission of the Executive Committee to use these certificates which will carry the Society's official seal.

A.S.M. Handbook Committee

It having been reported that representation on the American Society for Metals (A.S.M.) Handbook should consist of one rather than two members (see MECHANICAL ENGINEERING, June, 1944, page 426), J. H. Romann was named as that representative.

Book Reviews in "Mechanical Engineering"

The following vote of appreciation, taken by the Committee on Publications on the reviews of books by Prof. Ralph E. Freeman, of the Department of Economics of the Massachusetts Institute of Technology, over a period of nine years, was entered on the minutes of the Executive Committee, with the addition of its own "grateful appreciation for this splendid contribution to the engineering profession:" "To express its sincere appreciation and sense of deep gratitude to Prof. Ralph E. Freeman of the Department of Economics and Social

Sciences, Massachusetts Institute of Technology, and to his colleagues for their contributions of reviews of books on economic subjects which have materially broadened the view of readers of MECHANICAL ENGINEERING; for their faithful performance, month by month over a period extending from April, 1935, to May, 1944, of a task voluntarily assumed and without recompense; and for the extraordinary promptness with which these contributions were submitted."

Honors and Awards

Upon recommendation of the Board of Honors and Awards the following awards for 1944 were voted:

A.S.M.E. Medal to Edward G. Budd, "for the development of stainless-steel railway passenger cars."

Holley Medal, to Carl L. Norden, "for the invention and development of the Norden bombsight and other valuable devices which should hasten the peace."

Worcester Reed Warner Medal, to Earle Buckingham, "for his original contributions to engineering literature, especially in the fields of interchangeable manufacture and gearing."

Spirit of St. Louis Medal, to George W. Lewis, "for meritorious service in the advancement of aeronautics."

Spirit of St. Louis Medal

It was voted to present to the Institute of the Aeronautical Sciences a replica of the Spirit of St. Louis Medal.

Freeman Scholarship

The Secretary reported approval by the Freeman Fund Committee of the awarding of a Freeman Scholarship to a Chinese graduate in mechanical engineering "to pursue postgraduate study in the application of machinery to agriculture."

Appointments

The following appointments were reported:

Board of Honors and Awards, R. C. Muir, to fill the vacancy caused by the death of Geo. A. Orrok (to December, 1947).

Committee on Medals, Fred H. Colvin, to fill the vacancy caused by transfer of R. C. Muir to the Board of Honors and Awards.

Power Test Codes, W. W. Johnson, to fill the vacancy caused by the death of Geo. A. Orrok (to December, 1946).

Sectional Committee on Safety Code for Elevators A17, Joseph W. Degen.

Honorary chairmen of student branches: Lafayette College, Paul B. Eaton; University of New Hampshire, Tenko Kauppinen; University of Santa Clara, George L. Sullivan.

United Engineering Trustees, Inc., J. Schuyler Casey (four-year term).

Engineering Foundation, W. Trinks (four-year term).

ESTIMATED INCOME FOR 1944–1945 ADOPTED BY THE COUNCIL OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
JUNE, 1944

Income	Actual 1942–1943	Budget 1943–1944	Estimate 1944–1945
Initiation and Promotion Fees (to Surplus)	$ 13,008.42	$ 12,000.00	$ 12,000.00
Membership dues	241,594.17	240,000.00	235,000.00
Student dues	26,715.35	8,000.00	5,000.00
Interest and discount	4,547.16	5,000.00	4,000.00
MECHANICAL ENGINEERING advertising	178,457.30	180,000.00	160,000.00
Mechanical Catalog advertising	68,517.82	65,000.00	60,000.00
Publications sales	91,474.82	80,000.00	75,000.00
Contribution, *Journal of Applied Mechanics*	500.00	.....	.....
Engineering Index, Inc	798.60	1,356.00	1,000.00
Registration fees	405.00	822.00	500.00
Sale of equipment	35.00	.....	.....
Membership List advertising	.....	500.00	.....
Miscellaneous sales	1,684.79	2,500.00	1,500.00
Total Income	$614,730.01	$583,178.00	$542,000.00
To be added to surplus	59,329.72	16,060.00	6,629.35
Balance for Expense	$555,400.29	$567,118.00	$535,370.65

ESTIMATED BUDGET FOR 1944–1945 ADOPTED BY THE COUNCIL OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
JUNE, 1944

Activity	Expense under committee supervision	Printing and distribution	Direct office expense	Total
Council	$ 4,500.00	.....	.....	$ 4,500.00
Library	10,096.40	.....	.....	10,096.40
U.E.T. Deficit	7,000.00	.....	.....	7,000.00
Finance Committee	115.00	.....	.....	115.00
Nominating Committee	910.00	.....	.....	910.00
Awards	700.00	.....	$ 395.20	1,095.20
Local Sections	29,200.00	.....	8,163.33	37,363.33
Meetings and Program	8,500.00	.....	11,271.33	19,771.33
Professional Divisions	3,700.00	.....	11,021.33	14,721.33
Admissions	....	.....	9,796.67	9,796.67
Employment Reserve	2,000.00	.....	.....	2,000.00
Membership Development	2,500.00	.....	400.00	2,900.00
Aviation	....	.....	4,000.00	4,000.00
Student Branches	5,040.00	$ 1,000.00	5,052.14	11,092.14
Technical Committees	1,000.00	.....	23,100.00	24,100.00
Transactions	....	37,200.00	16,471.00	53,671.00
MECHANICAL ENGINEERING, text	....	29,000.00	14,130.00	43,130.00
Membership List	....	7,000.00	1,300.00	8,300.00
MECHANICAL ENGINEERING, advertising	....	34,100.00	37,961.33	72,061.33
A.S.M.E., Mechanical Catalog	....	23,000.00	27,635.33	50,635.33
Publications for Sale	....	30,500.00	11,917.34	42,417.34
Reserved for Boiler Code	....	5,000.00	.....	5,000.00
Retirement Fund	7,700.00	.....	.....	7,700.00
E.C.P.D.	850.00	.....	.....	850.00
General committee expense	100.00	.....	.....	100.00
Professional services	1,500.00	.....	.....	1,500.00
Committee on Registration	350.00	.....	.....	350.00
Organization charts	125.00	.....	.....	125.00
Publicity	6,000.00	.....	.....	6,000.00
Secretary	....	.....	18,300.00	18,300.00
Accounting	....	.....	21,393.00	21,393.00
General service	....	.....	34,567.00	34,567.00
General office	....	.....	19,809.25	19,809.25
	$91,886.40	$166,800.00	$276,684.25	$535,370.65

Make Reservations Early for Joint Fuels Conference

THE Annual Joint Fuels Conference of the A.S.M.E. Fuels Division and the A.I.M.E. Coal Division will be held at Charleston, West Virginia, on October 30 and 31, 1944. The available hotels are the Daniel Boone, the Kanawha, and the Ruffner. It is advisable to make hotel reservations as early as possible.

Stevens Honors Three A.S.M.E. Members

AT its 72nd commencement exercises on June 27 Stevens Institute of Technology conferred the honorary degree of Doctor of Engineering upon John B. Klumpp, the honorary degree of Doctor of Science upon Prof. Kenneth S. M. Davidson, and the honorary degree of Mechanical Engineer on Joseph Haag, Jr. All three are members of the A.S.M.E.

Mr. Klumpp is a consulting engineer in Philadelphia, Professor Davidson is in the mechanical-engineering department of Stevens Institute and is director of the Experimental Towing Tank Laboratory, and Mr. Haag is vice-president of the Todd Shipyards Corporation.

Co-Operation at the Grass Roots

OUR profession of engineering has many branches and specialties. Nevertheless it is one profession with a common foundation of general scientific training, a common way of approach to professional tasks, and a common concern with applying the materials and forces of nature to the service of mankind. We must recognize and use this community of interest if we are to realize fully our opportunities for influence and service.

At the national level we have co-operation, for various purposes, of the societies representing branches of engineering. Four national engineering societies co-operate in The Engineering Foundation, in the Engineering Societies' Library, in United Engineering Trustees, and in Engineering Societies' Personnel Service. Five co-operate in the Engineers' Council for Professional Development besides the Society for the Promotion of Engineering Education, The National Council of State Boards of Engineering Examiners, and The Engineering Institute of Canada. Three national engineering societies work actively with the American Standards Association and the National Committee of the International Electro-Chemical Association. Our own Society also joins other engineering societies and related organizations in making certain awards. And we are associated with management organizations in the National Management Council.

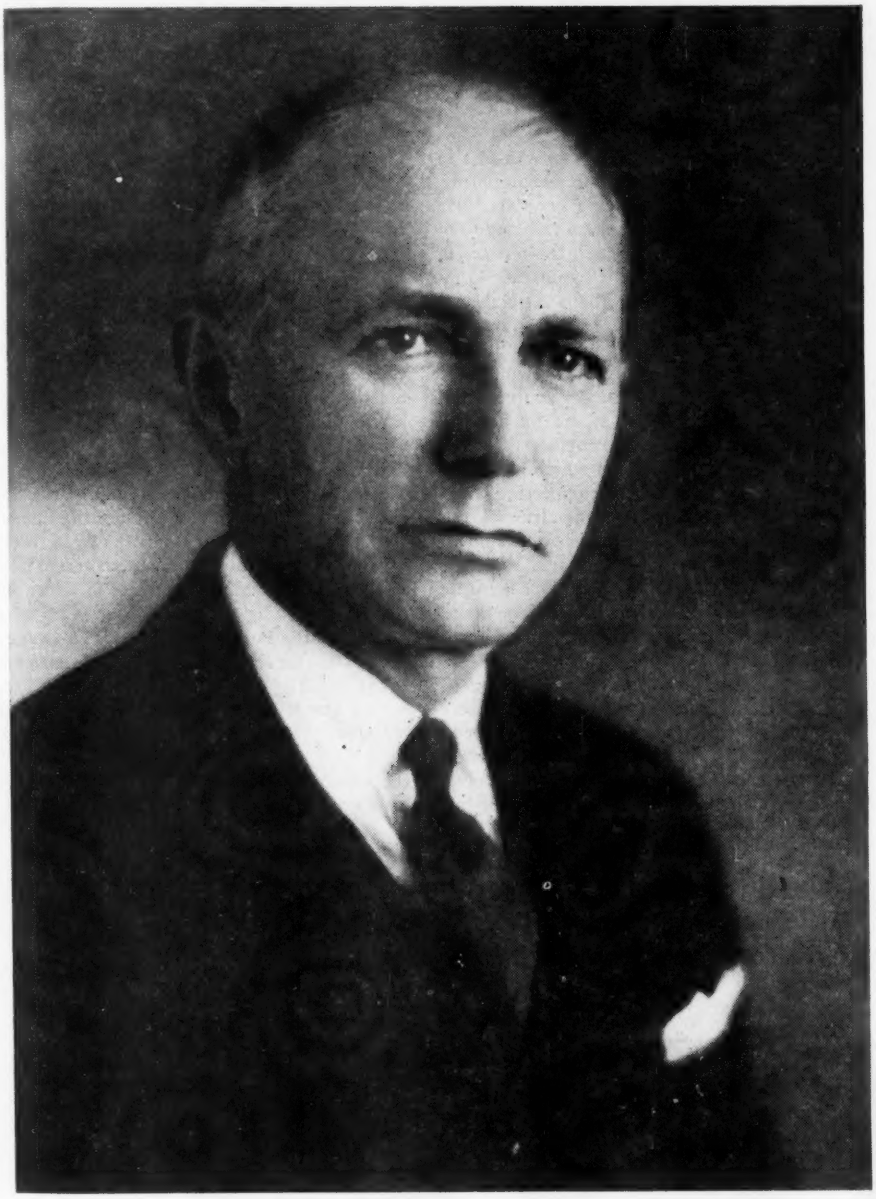
These joint activities, however, are carried on mainly by participation of national representatives in a national group. Some engineers come together and work together throughout the country in sectional and community groups to furnish a firm foundation for such joint efforts. It is true that these are the exception rather than the rule; for example, the Engineers' Society of Western Pennsylvania, the occasional joint regional or local conferences of two or three engineering groups, and some highly co-operative local engineering clubs or groups. These exceptions point up the desirability and demonstrate the feasibility of active engineering councils in every community where there are engineers in considerable numbers.

For there are things for engineers within a community to do together—not as mechanical, or civil, or electrical, or mining, or chemical, or automotive engineers—but as members of the engineering profession and as a group conscious of collective responsibilities. There are problems of re-employment and employment counseling and educational guidance. There are countless other community, social and economic, and political problems that need the application of the engineering mind. If a city or county medical society, or bar association, or teachers' association is not only important to the professional welfare of its members but also useful as an agency for advice and influence and action in community service, then surely engineers, in this engineering age, should co-operate likewise and show that we do in reality belong to a profession dedicated collectively as well as individually to public service.

There are not only local community problems, but also state and national problems, which should be explored by the members of our profession and on which the collective mind of our profession should find expression. We have helped to create many of these problems; we must help solve them.

This cannot be done in the national offices of our societies or in national joint committees. The motive power must come from the grass roots of the profession.

(*Signed*) R. M. GATES, *President, A.S.M.E.*



Alex D. Bailey

Nominated for President

A.S.M.E. OFFICERS *Nominated for* 1944-1945

DURING the 1944 Semi-Annual Meeting of The American Society of Mechanical Engineers in Pittsburgh, Pa., June 19–22, Alex D. Bailey, vice-president of the Commonwealth Edison Company, Chicago, Ill., was nominated by the National Nominating Committee for the office of President of the Society for the year 1944-1945.

Vice-presidents named by the Committee to serve two-year terms on the Council of the A.S.M.E. were David Larkin, St. Louis, Mo., John E. Lovely, Springfield, Vt., and Thomas S. McEwan, Chicago, Ill.

Managers of the Society to serve on the Council for three-year terms included Daniel S. Ellis, Lima, Ohio, Arthur J. Kerr, Tulsa, Okla., and Herman G. Thielscher, Washington, D. C.

Members of the Committee making the nominations were: Frank O. Hoagland, West Hartford, Conn., chairman, representing Group I; John P. Magos, Chicago, Ill., secretary, representing Group VI; George J. Nicastro, New York, N. Y., Group II; J. Stanley Morehouse, Villanova, Pa., Group III; A. M. Ormond, Savannah, Ga., Group IV; Darwin S. Brown, Cincinnati, Ohio, Group V; Alf Hansen, San Francisco, Calif., first alternate, Group VII; and H. L. Crain, Kansas City, Mo., Group VIII.

Election of A.S.M.E. officers for 1944-1945 will be held by letter ballot of the entire membership, closing September 26, 1944.

Biographical sketches of the nominees follow on the succeeding pages.

Nominated for President

Alex D. Bailey

ALEX D. BAILEY, nominee for President of The American Society of Mechanical Engineers, is a Fellow of the Society and is vice-president in charge of operations and engineering of the Commonwealth Edison Company, Chicago, Ill. He was born in Kenosha County, Wis., February 14, 1882, but his family moved to Chicago when he was about seven years old. He acquired his grammar-school and high-school education in Chicago and in Glen Ellyn, Ill., and completed his undergraduate work at Lewis Institute, where he received the degree of mechanical engineer in 1903.

The honorary degree of doctor of science was accorded him at the dedication of The Technological Institute of Northwestern University in 1942.

He entered the employ of the Commonwealth Edison Company in 1903, at Harrison Street Station, and progressed successively through the positions of chief engineer of the Fisk and Quarry Stations, superintendent of generating stations, chief operating engineer, assistant to vice-president, and, since July 1, 1944, has been vice-president. Throughout this period of participation in the management of large steam-station generating equipment, he has contributed to many improvements in the design and operation of special equipment, and to advances in operating practices. He has been a member and chairman of many important operating and research committees in the Association of Edison Illuminating Companies, National Electric Light Association, and Edison Electric Institute.

Mr. Bailey has long been interested in engineering education and is well known to the faculties of engineering colleges and universities in the Middle West, where he has frequently addressed student engineers on the broader aspects of education which are so advantageous in making the engineering graduate a better and more useful citizen. For nearly four years he was chairman of the Board of Trustees of Lewis Institute and, since the merger of that institute with Armour Institute in 1940, he has been vice-chairman of the Board of Trustees of the Illinois Institute of Technology.

From the time he became a junior member of The American Society of Mechanical Engineers in 1910, Mr. Bailey has had a keen interest in its advancement, his first active participation in its affairs occurring in 1917, when he became vice-chairman of the Chicago Section, the following year being elected chairman. Among other offices he has held in the Society since that time are vice-chairman, and chairman of the Power Division, 1922 and 1923, respectively; delegate, International Fuel Conference London, 1928; member, 1929–1934, and chairman of the Standing Committee on Research, 1934; manager, 1933–1935; Fellow, 1936; vice-president, 1936–1937; chairman, Special Council Committee; Advisory Board on Standards and Codes, 1935–1937. He is still active on a number of standing committees which concern either research, or education and training. He is also a member of the Western Society of Engineers, and of the Society for the Promotion of Engineering Education. He is a member of Tau Beta Pi fraternity.

Mr. Bailey has always taken an active part in the affairs of the communities in which he has lived, having served for four years as a member of the Board of Trustees of La Grange Park, Ill. He served for 14 years as a member of the Board of Trustees of La Grange Illinois, during the last two years of which he was president. He is a member of the La Grange Civic Club, the La Grange Country Club, and the Union League Club of Chicago, of which he is a past-director and vice-president.

Nominated for Vice-Presidents

DAVID LARKIN

JOHN E. LOVELY

THOMAS S. MC EWAN

David Larkin

DAVID LARKIN, vice-president and general manager of Broderick & Bascom Rope Company, St. Louis, Mo., has been nominated for the office of Vice-President of The American Society of Mechanical Engineers. Mr. Larkin, who was born on April 21, 1880, at Bootle, England, and received his primary education in Edinburgh, Scotland, and graduated from Queens College, Belfast, Ireland, in 1902, came to the United States immediately thereafter, and was naturalized as a citizen in 1903. From 1903–1905, he was engaged as a mechanical draftsman and assistant mechanical engineer with the New York Central Railroad. With this beginning, his career has been an active and varied one. In the years 1905–1907, he was with the Wilson Company Packing House, New York, N. Y.; 1907–1909, outside field engineer with Patterson Brothers, Consulting Engineers, New York, N. Y., 1909–1913, chief engineer, Fifth Avenue Building Company, New York, N. Y., in charge of operations; 1913–1915, chief mechanical and electrical engineer of various plants of the New York-Pennsylvania Pulp & Paper Company; 1915–1917, chief mechanical engineer, Fifth Avenue Building Company; 1917–1923, chief engineer in charge of all operations, Monsanto Chemical Works, St. Louis, Mo.; 1923–1928, consulting engineer in St. Louis.

During this period, Mr. Larkin designed and supervised the construction of many industrial plants throughout the Middle West, outstanding among which are the Illinois Powder Company; Becker Paint & Varnish Company, Cincinnati, Ohio; Alligator Clothing Company, St. Louis; Saxony Flour Mills, St. Louis; Broderick & Bascom Rope Company; and many others.

In his present position as vice-president and general manager of the Broderick & Bascom Rope Company, which connection began in

1928, Mr. Larkin has been instrumental in enlarging and broadening the scope of the engineering staff and services of the company. He has completed a number of machinery programs for modernization of plant facilities and has been actively engaged in furthering the development and standardization of wire-rope specifications for the entire industry, as well as for specific requirements of customers of the company.

Mr. Larkin became a member of The American Society of Mechanical Engineers in 1921 and a Life Member in 1943. His activities in the Society have included past-chairman of the St. Louis Section; member of Membership Development Committee; member of the A.S.M.E. War Production Board Committee since its inception; general chairman of the First National Defense Meeting of the A.S.M.E. held in St. Louis in 1941. He also holds membership in the following societies and clubs: American Society for Testing Materials; Wire Rope & Strand Manufacturers Association; Board of Directors of the St. Louis Branch of the National Metal Trades; Navy League of the United States; Army Ordnance Association; Newcomen Society; Missouri Athletic Club; St. Louis Chamber of Commerce; American Petroleum Institute; Industrial Club of St. Louis; Advisory Board, Washington University School of Engineering, St. Louis, Mo., and a member of Enterprise Masonic Lodge No. 48, Jersey City, N. J., since 1909.

Thomas S. McEwan

THOMAS SPRING McEWAN, consulting management engineer of Chicago, Ill., who has been nominated for the office of vice-president of The American Society of Mechanical Engineers, was born on April 1, 1889, in Jersey City, N. J. After the usual education in grade and high schools, he entered Cornell University from which he was graduated in 1911 with the degree of mechanical engineer.

His first position was as an engineer in the West Lynn, Mass., plant of the General Electric Company. In 1915, he became assistant sales manager of the SKF Manufacturing Company, being stationed in New York, N. Y., and Hartford, Conn. When the United States declared war in 1917, he saw service as a Second Lieutenant in the Aviation Section, S.R.C., U. S. Army. Upon his discharge from the Army, he accepted a position as Chicago district sales manager with the Cowan Truck Division, Yale & Towne Manufacturing Company.

In 1925, Mr. McEwan joined the Haynes Corporation, Chicago, Ill., as a consulting management engineer and senior vice-president. In 1933, he became connected with Stevenson, Jordan & Harrison, New York and Chicago, as resident manager engineer and management counselor. His work throughout the Middle West has covered all phases of management engineering. In 1940, and subsequent to his government service, he continued his consulting work with McClure, Hadden & Ortman, Inc., Chicago, Ill., of which firm he is vice-president.

Because of his extensive knowledge of the facilities, equipment, and personnel in plants throughout the Midwest area, Mr. McEwan was selected to set up the War Production Board, as Regional Director of the Seventh Federal Reserve District in early 1941.

He has been a member of the Society since 1915. Mr. McEwan has found time to take part in the activities of the Chicago Section, serving as chairman for three years, 1936–1938. He was elected a Manager of the Society in 1941. At present, he is the charter president of the newly organized Chicago Technical Societies Council.

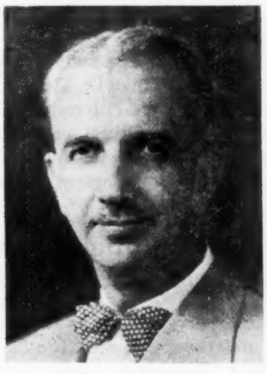
John E. Lovely

JOHN EMERSON LOVELY, vice-president and chief engineer of Jones & Lamson Machine Company, Springfield, Vt., nominated for Vice-President of The American Society of Mechanical Engineers, was born August 1, 1888, at Tottenville, N.Y. He graduated from the University of Vermont, Burlington, Vt., in 1910, with the degree of bachelor of science in mechanical engineering; Phi Beta Kappa honors. From 1910 to 1916, Mr. Lovely was chief engineer of the Patch Manufacturing Company, Rutland, Vt., followed by a year as superintendent of the Fort Dearborn Manufacturing Company, Sterling, Ill. In 1917–1918, he supervised the manufacture of shells at the Vermont Farm Machine Company. From 1918 until the present time he has been with Jones & Lamson Machine Company, Springfield, Vt., of which he is now vice-president and chief engineer.

Mr. Lovely was president of the National Machine Tool Builders' Association in the period 1939-1940. He is a member of The Council of the American Standards Association; a member of the American Society of Tool Engineers; and a member of various committees of The American Society of Mechanical Engineers.

Nominated for Managers

DANIEL S. ELLIS



A. J. KERR

H. G. THIELSCHER

Daniel S. Ellis

DANIEL S. ELLIS, nominated for the office of Manager of The American Society of Mechanical Engineers, was born at Warwick, N. Y., on January 25, 1897, and attended the Warwick High School. In 1916, he became a clerk in the auditor's office of the Lehigh & Hudson River Railway and, in the following year, was appointed a clerk in the office of the auditor of freight accounts of the New York Central Railroad. Later he served as a machinist and as an acting enginehouse foreman.

In 1918, Mr. Ellis became a draftsman, serving in this position and as an engineer, calculator, designer, and traveling engineer until 1924. In that year, he was appointed assistant engineer of motive power, New York Central Lines. On May 1, 1929, he left the employ of the New York Central and accepted the position of eastern district manager, and subsequently manager, of the railroad division of the Worthington Pump and Machinery Corporation. On October 1, 1932, he resigned from the latter position to become engineer of motive power on the Advisory Mechanical Committee of the Chesapeake & Ohio; Erie; New York, Chicago & St. Louis; and Pere Marquette railways with headquarters at Cleveland, Ohio.

In January, 1936, Mr. Ellis was appointed mechanical assistant to the vice-president of

the C.&O., N. Y. C. & St. L., and P.M. railways with headquarters in Cleveland, and in July, 1936, was appointed chief mechanical officer of the same roads, which position he held until May 1, 1943, on which date he resigned to become vice-president in charge of manufacture, Lima Locomotive Works, Incorporated, Lima, Ohio.

Mr. Ellis has served as a member of the General Committee, Mechanical Division, Association of American Railroads, chairman of the Committee on Further Development of Reciprocating Steam Locomotives, and on various subcommittees of that association. He also has been chairman of the Railroad Division of The American Society of Mechanical Engineers, and is now a member of the War Production Committee of the Society. He is a member of various railroad clubs; the Newcomen Society of America and England; past-president of the Cleveland Roamers; The Chicago Club, Chicago, Ill.; The Lima Club; and Shawnee Country Club, Lima, Ohio.

A. J. Kerr

A. J. KERR, district manager of the Pittsburgh Equitable Meter Company, Tulsa, Okla., and a candidate for the office of Manager of The American Society of Mechanical Engineers, was born in Armstrong County, Pa., November 26, 1897, and attended public school and high school in Kittaning, Pa. He attended Carnegie Institute of Technology, Pittsburgh, Pa., from 1917 to 1920, graduating with a bachelor of science degree in mechanical engineering. Until April, 1921, he was a draftsman with the C&G Cooper Company, Mt. Vernon, Ohio, from which time until 1925 he was associated with the Foxboro Company of Tulsa, Okla., as a sales engineer. During the next two years he served as district manager at Tulsa for the Equitable Meter and Manufacturing Company, and from 1926–1932 in the same post after the merger of the Equitable Meter and Manufacturing Company with the Pittsburgh Meter company. From 1932 to the present time, he has been district manager of the Pittsburgh Equitable Meter Company, and also of the Merco Nordstrom Valve Company, with jurisdiction over the States of Arkansas, Louisiana, Texas, New Mexico, and Oklahoma.

Mr. Kerr has served as treasurer, secretary, and chairman of the Mid-Continent Section of the A.S.M.E. He also served for five years on the Local Sections Committee, and for eight years has been a member of the Fluid Meters Committee. He is a past-president of the Engineers Club of Tulsa and is now serving on its board of directors.

H. G. Thielscher

H. G. THIELSCHER, nominated for the office of manager of The American Society of Mechanical Engineers, was born at Boston, Mass., February 22, 1893. He was graduated from Lowell Institute, receiving certificates in mechanical engineering in 1913 and electrical engineering in 1915.

From 1911 to 1916 while obtaining his technical education, Mr. Thielscher held positions in the fuel-engineering and test department of Arthur D. Little, Inc., and in the design department of the Submarine Signal Company. From 1916 to 1922 he was employed by the Stone & Webster Engineering Corporation as mechanical engineer engaged in design of power plants, industrial plants, reports and appraisals.

In 1922 Mr. Thielscher was selected by McClellan & Junkersfeld, Inc., to head their mechanical-engineering department until the firm was dissolved in 1929. During his term with this company, he was responsible for the design of many important engineering works, the most notable of which is the Cahokia Power Plant of the Union Electric Company of Missouri. This was one of the first large central stations to be designed for the use of pulverized coal. Another notable central station completed under his charge was the Hunters Point Plant of the Pacific Gas & Electric Company. This was the first large central station designed for quick-start duty.

In 1929 Mr. Thielscher returned to the Stone & Webster Engineering Corporation, engaging mainly in consulting work, reports, and new business activities on the Pacific Coast. In 1933 he joined the staff of the Potomac Electric Power Company, Washington, D. C., as mechanical engineer, responsible for design and operation of steam generating plants. Since 1940 he has served this company as consultant on operation and as mechanical engineer in charge of the company's generating-plant expansion program required to meet the rapid increase in demands.

Mr. Thielscher became a member of The American Society of Mechanical Engineers in 1923. He served one term as chairman of the Washington, D. C., Section of the A.S.M.E. from 1939 to 1940. He was the author of a paper entitled "Pulverized-Fuel-Burning Experiences at Buzzard Point Station," presented at the 1934 A.S.M.E. Annual Meeting in New York and has written many articles for the technical press. He has been a special lecturer at George Washington University and was a member of the United States National Committee on Steam Turbines in 1939. Mr. Thielscher became a licensed professional engineer in New York State in 1925.

Among the Local Sections

Preparatory Courses for Engineering

Indiana Section Meets With High-School Officials and Students to Outline Work Essential to Pursuit of Engineering Degrees in College

AN extremely successful meeting on the subject of "Vocational Guidance for High-School Students," was conducted at the final session of Central Indiana Section on June 7, at Arsenal Technical High School, Indianapolis, Ind. The meeting was attended by 70 high-school students, the executive assistant to the superintendent of the Indianapolis public schools, and the principals of the Indianapolis high schools.

The meeting was of the panel-discussion type under the chairmanship of Dr. Donald B. Prentice, president of Rose Polytechnic Institute, Terre Haute, Ind. Other members of the panel were Dr. W. A. Hanley, director of engineering, Eli Lilly & Company, Indianapolis, Ind., and Prof. W. E. Vogler, director of personnel, Schools of Engineering and Science, Purdue University, West Lafayette, Ind.

Under the guidance of President Prentice, many phases of engineering were presented in sufficient detail for each branch to provide a comprehensive analysis. Dr. Hanley, representing industry, discussed the professional advantages of an engineering degree and outlined the inherent opportunities in industry within reach of the engineering graduate. Professor Vogler presented the subject from the standpoint of the engineering curriculum and outlined the preparatory courses in high school essential to the pursuit of an engineering degree in college.

Material Handling Featured at Anthracite-Lehigh Valley

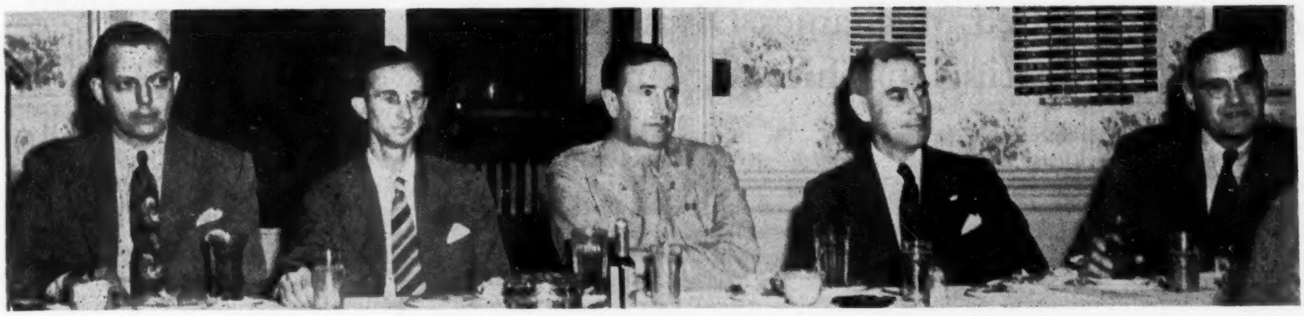
Alfred B. Ueker of the Murray Corporation gave an illustrated talk on "The Mechanical Handling of Materials as Applied to Aircraft Construction," at the May 26 meeting of the Anthracite-Lehigh Valley Section. Mr. Ueker explained the application and development of automotive methods to aircraft construction and the use of conveyer systems for mass production in this field.

"Ladies' Night Program" Held at Baltimore Section

Billy Repaid, news commentator on station WOL, Washington, D. C., was guest speaker at the ladies' night program given by the Baltimore Section on May 22, at the Engineers Club of Baltimore, Baltimore, Md. Mr. Repaid gave an interesting talk on current events, quoting logical reasons for certain occurrences that "make the headlines," and making some long-range predictions concerning the political situation and the war.

Braking Problems Outlined at Colorado Section

An interesting and instructive talk on "Braking of High-Speed Trains," was given by D. R. Collins of the Westinghouse Air Brake Company, Wilmerding, Pa., at the June 16 meeting of the Colorado Section, in the Oxford Hotel, Denver, Colo. Following Mr. Collins' comments, members and guests viewed the motion picture "Railroadin," lent through the courtesy of General Electric Company, Schenectady, N. Y., and American Locomotive Company, New York, N. Y.



SPEAKERS' TABLE AT THE KINGSPORT MEETING, MAY 26, OF EAST TENNESSEE SECTION
(*Left to right:* Roscoe W. Morton, James E. Rigley, Lieut. Col. Francis R. Scherer, Carey H. Brown, and James C. White.)

Dayton Section Inspects Magnesium Plants

Forty-five members and guests of the Dayton Section on June 15 enjoyed a very interesting inspection trip through the Parker Pattern & Foundry Company, and the Steel Products Engineering Company, to see magnesium cast and machined, after which a short meeting was held to honor those holding life membership in the A.S.M.E.

East Tennessee Section Learns of Ordnance Matériel

Lt. Col. F.R. Scherer spoke on the subject of "Development and Production of U. S. Army Ordnance Matériel," at the May 26 meeting of the East Tennessee Section. This Section met again on May 31, to hear Prof. F. H. Thomas speak on "Statistical Methods of Quality Control."

Honolulu Section Hears Plans for New Airport

At an overflow luncheon meeting on June 2, held by the Honolulu Section in the Commercial Club, Honolulu 54, Hawaii, Robert Campbell and Benjamin F. Rush spoke on plans for the Keehi Lagoon Airport. Mr. Campbell, among other things, pointed out that Keehi Lagoon was chosen for the site of a new airport because it is free from surrounding hazards, close to town, and of adequate size. Mr. Rush reported that $50,000 had been appropriated by the last Territorial Legislature for getting out plans for the terminal building at Keehi Lagoon Airport, which plans, however, are being held in abeyance pending a visit to the mainland to see the work carried out there. The need for the airport is apparent, since inter island air freight now amounts to 500,000 pounds monthly, and the future possibilities cannot be predicted. At a meeting on June 9, Commander Samuel Wilder King, U.S.N., who had just returned from a tour of the Marshall Islands battle zone, was scheduled to speak on "Current Events." The report of this meeting has not yet been received, but on the many occasions in the past that Commander King has addressed this Section he has been enthusiastically received.

Annual Dinner Meeting Held by Louisville Members

Louisville members and their wives attended the annual dinner meeting held at the Pendennis Club, Louisville, Ky., on June 1. Dr. E. W. Jacobsen, guest speaker of the evening, spoke on the subject of "The Universities Place in Louisville's Future." Dr. Jacobsen, who is president of the University of Louisville, greatly impressed those in attendance with his outline of a three-fold purpose of the university, i.e., to convey the best of the past to the youth; to bring out the boundaries of truth by research, and to facilitate continual education by adult-education programs.

This Section held its regular monthly meeting on June 16, at the Gulf Club House, Cherokee Park, Louisville, Ky., at which L. P. Aker and Dr. Charles Strull, members and past-presidents of the Louisville Astronomical Society, gave an illustrated account of "Amateur Astronomy as an Engineering Hobby."

Science of Philately Heard by Mid-Continent Section

The Tulsa Stamp Club was guest of the Mid-Continent Section on June 2, at the Tulsa Chamber of Commerce Dining Hall, Tulsa, Okla. Dwight O. Barrett, chief mechanical engineer, the Gulf Oil Corporation, New York, discussed the science of philately, and exhibited many stamps to bear out his own views of stamp collecting.

New Officers Elected for Milwaukee Section

At the regular meeting on May 10, the Milwaukee Section voted unanimously to office for the 1944–1945 term the panel proposed by the nominating committee. The committee had proposed Robert Cramer, Jr., as chairman; Sebastian Judd, secretary, and Theodore Wetzel, treasurer. Directors for one term are Max Reuss and M. K. Drewry; two-year term, George Minniberger and E. A. Huber; three-year term, Samuel Gates and Dr. J. T. Rettaliata. According to Robert Cramer, Jr., chairman, plans are under way for a very active season starting this fall. The Oil and Gas Power Division of the A.S.M.E., at its Executive Committee Meeting in Tulsa, Okla., May 8–10, 1944, voted to accept this Section's invitation to hold its 1945 Spring Convention in Milwaukee. At a Ladies' Night Dinner meeting on June 21, G. William Longenecker of the University of Wisconsin was scheduled to speak on the subject of "Romance of the Landscaped Home and a Designed Garden." The report of this dinner meeting, held in the Pfister Hotel, Milwaukee, has not yet been received.

Prof. F. B. Rowley Honored by Minnesota Section

In recognition of accomplishments in engineering education and research in the field of heating and ventilating, the Minnesota Section at its Annual Meeting on June 15 awarded a Certificate of Recognition to Prof. Frank B. Rowley, head of the mechanical-engineering department at the University of Minnesota. Professor Rowley responded with remarks on the importance of The American Society of Mechanical Engineers to the engineering profession and on the importance of co-operative effort in research work done at the University.

His career at the University of Minnesota started in 1904, when he accepted a position as instructor of drawing and descriptive geometry. He served as assistant professor and then professor of various departments until 1941, when he was appointed to his present position. The principal fields in which Professor Rowley has done research are the heating properties of domestic radiators, air contamination and filtration, building ventilators, thermal conductivity of building materials and wall sections, domestic air conditioning, and moisture transfer through building wall.

Combustion Film Shown at St. Louis Section

The May 26 meeting of the St. Louis Section was held jointly with the St. Louis organization of the National Association of Power Engineers. Otto de Lorenzi of Combustion Engineering Company, Inc., New York, N. Y., presented a colored motion picture which depicted actual furnace conditions, burning a wide variety of fuels. Mr. de Lorenzi has been with Combustion Engineering Company since June, 1919, and is at present educational director.

West Va. Section Hears Induction Heating Explained

A dinner meeting was held on May 23, last of the 1943–1944 season, by the West Virginia Section at the Daniel Boone Hotel, Charleston, W. Va. Dr. H. B. Osborn, Jr., head of research and sales development of the Tocco Division of the Ohio Crankshaft Company, was guest speaker and gave an interesting and informative talk on "Induction Heating at War Today—at Peace Tomorrow." The principles underlying the Tocco induction heating process, as well as the possible application of this process, were thoroughly reviewed, and specific examples of heat-treating, normalizing, brazing, forging, and forming were explained.

A.S.M.E. Applied Mechanics Division Holds National Meeting in Chicago, June 16-17

THE eleventh National Meeting of the Applied Mechanics Division of the A.S.M.E. was held in Chicago, June 16 and 17. The meetings were held under the auspices of the Illinois Institute of Technology and the Chicago Section of the Society. The local committee included Prof. C. O. Harris, chairman, L. V. Griffis and V. L. Streeter of the Illinois Institute, and C. O. Dohrenwend and W. E. Wilson of the Armour Research Foundation. The success of the meeting is due to the efforts of Professor Harrison and his committee.

Three technical sessions were held dealing with elasticity, plasticity, and electrical optical and numerical stress analysis, with a dinner on the evening of June 16 and a visit to the Illinois Institute of Technology on the afternoon of June 17. The number registered at the meetings was 101 with 62 attending the dinner.

Electrical Circuits and Stress Problems

The papers were well received and considerable discussion took place at each session. The interests represented by the authors were somewhat varied, including problems of the aircraft, concrete, steel-drawing, and electrical industries. The papers in the latter group dealt with the application of electrical circuits to the solution of stress problems. This is a new field of activity for the Division, and one capable of further development.

The Executive Committee met in the afternoon of June 16 and discussed plans for the 1944 Annual Meeting. This meeting was attended by J. H. Keenan, chairman, J. N. Goodier, R. Eksergian, J. M. Lessells, W. M. Murray, A. Nadai, R. E. Peterson, and H. Poritsky. Ernest Hartford attended from A.S.M.E. headquarters.

After-Dinner Talks

After the dinner, a few remarks of welcome were offered by Dr. Henry T. Heald, president of Illinois Institute of Technology, and by T. S. McEwan, member of Council of the Society. These remarks were followed by a very interesting paper by Prof. H. F. Moore, University of Illinois, entitled "Five Notable Figures in Applied Mechanics of Materials." This paper emphasized the importance which such historical work has in the material problems of today.

A.I.E.E. Officers for Coming Year

CHARLES A. POWEL, manager, Headquarters engineering departments, Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., was elected president of the American Institute of Electrical Engineers for the year beginning August 1, 1944, as announced at the annual meeting of the A.I.E.E. held in St. Louis, Mo., during the summer technical meeting of the Institute. The other officers elected were: vice-presidents R. T. Henry, Buffalo, N. Y.; J. F. Fairman, New York, N. Y.; M. S. Coover, Ames, Iowa; R. W. Warner, Austin, Texas; C. B. Carpenter, Portland, Ore.; directors P. L. Alger, Schenectady, N. Y.; M. J. McHenry, Toronto, Canada; D. A. Quarles, New York, N. Y.; national Treasurer, W. I. Slichter, New York, N. Y. (re-elected).

A.S.M.E. Calendar

of Coming Meetings

October, 2-4, 1944
A.S.M.E. Fall Meeting
Cincinnati, Ohio

October, 30-31, 1944
Joint Meeting of A.S.M.E.
Fuels and A.I.M.E. Coal
Divisions, Charleston, West Va.

November 27-December 1, 1944
A.S.M.E. Annual Meeting
New York, N. Y.

(For coming meetings of other organizations see page 42 of the advertising section of this issue)

Allcut Succeeds Angus at Toronto

ANNOUNCEMENT has been made of the appointment of Prof. E. A. Allcut, member A.S.M.E., as head of the department of mechanical engineering in the Faculty of Applied Science and Engineering, University of Toronto, Toronto, Ontario, Canada to succeed Prof. R. W. Angus, honorary member A.S.M.E., who retired on June 30. Professor Allcut is past-chairman of the A.S.M.E. Ontario Section.

Chinese Engineers Hold Annual Banquet in New York

THE Chinese Institute of Engineers, America Section, held its annual convention banquet at the Hotel New Yorker, New York, N. Y., on July 3, 1944. R. F. Gagg and W. G. Christy, members of the A.S.M.E. Council, attended the banquet as representatives of The American Society of Mechanical Engineers.

Speakers at the banquet included L. F. Chen, president C.I.E., America Section, well known to engineers in New York City; Paul B. Eaton, former member of the A.S.M.E. Council, who recently returned from a mission in China; Nevin E. Funk, president A.I.E.E.; and Dr. Ting-Fu Tsiang, China's chief delegate to the United Nations Relief and Rehabilitation Administration.

The Chinese Institute of Engineers was founded in China thirteen years ago. At present C.I.E. has 700 members and 35 sections scattered over 14 provinces in China. The America Section has established 12 local chapters in the United States since 1942. Semiannually the America Section publishes the *C.I.E. Journal* and bimonthly the *C.I.E. News Bulletin*. Close co-operation has been established between the C.I.E. and several engineering societies in the United States, including A.S.M.E.

The banquet was part of the three-day program of the annual convention.

With the Student Branches

Fire-Fighting Discussed at California Branch

THE last meeting of the UNIVERSITY OF CALIFORNIA BRANCH was held on June 8, at which members heard Mr. Hough of Walter Kidde & Company, New York, N. Y., discuss the various types of fire extinguishers, their respective advantages and disadvantages. An interesting motion picture, "Fighting Fires," was also viewed by those in attendance. Prior to Mr. Hough's remarks, it was decided to hold election of officers by mail, the results of which were released by George Anisman, secretary of the Branch, on June 16, as follows: Chairman, Basil Garrett; vice-chairman, Frank Klock; secretary, Eugene Dixon, and treasurer, Bob delongh.

The COLUMBIA BRANCH met on June 2 to elect new officers for the coming semester, and to prepare a schedule of programs for the new term. The newly elected officers are: Chairman, Nicholas Mikhalevsky; vice-chairman, Kurt Minati; secretary, Alan Schanes, and treasurer Robert Schaefer.

On May 30, Prof. J. N. Goodier, of the Mechanics Department, CORNELL BRANCH, gave a very interesting lecture on "Dynamical Problems in Engineering." Various difficulties encountered in locomotives in motion were discussed, as well as vibrating shafts and irregularly shaped objects. This Branch held a special meeting on June 8, to hear Otto de Lorenzi speak on "A Study of Stoker Fuel Beds." Mr. de Lorenzi illustrated his interesting talk with motion pictures depicting the actual combustion of coal in furnaces.

Officers at Duke

After a brief business meeting on June 6, members of DUKE BRANCH elected new officers for the coming semester as follows: President, Gil Branden; vice-president, W. S. Williams; secretary, A. C. Alperin, and treasurer, A. C. Elkins.

All officers elected during the week of May 27 by the UNIVERSITY OF ILLINOIS BRANCH are for the summer term—July to November, except the treasurer, whose term expires in February, 1945. The new officers are: President R. W. Fouts; vice-president, A. L. Clark; secretary, J. C. McGrath, and treasurer, C. R. Rankin.

Railroads and Weather at Kansas

The featured speaker at the June 1 meeting of Kansas University Branch was Walter Bohnstengel, chief engineer of tests for the A.T. & Santa Fe Railroad. Mr. Bohnstengel devoted his talk to railroading, discussing especially the testing of locomotives and the track. Diverting from the main theme, he touched on the effect of the solar system upon the weather in Kansas.

Maryland Branch met for its last meeting of the spring semester on June 7, at which a motion picture, "Building a Bomber," was shown. Prior to viewing the film, members elected new officers as follows: Irwin Douglas Cook, president; Arnold Seigel, vice-president; Roberta Flanigan, secretary, and Kent Kise, treasurer.

Massachusetts Tech Learns of Jet Propulsion

A summary of the term's work of the Massachusetts Tech Branch was reported on June 8 by F. R. Berry and G. M. Condie of the Publicity Committee. At the first meeting Prof. Dean M. Fales spoke on the subject of "The Future of the Automotive Industry." At the second meeting officers were elected and included Warren J. Harwick, president; Allan B. Wolfe, vice-president; William B. Meade, secretary; and Walter F. Limbach, treasurer. Also at this meeting members heard Prof. John A. Hrones, honorary chairman, explain the principles of the servo-mechanism as applied to ordnance fire control. Professor Hrones demonstrated this application by the use of a small experimental model. This Branch next sponsored a series of three lectures, at the first of which Prof. J. H. Keenan gave the basic thermodynamic principles involved in jet propulsion. The second lecture featured Prof. C. R. Soderberg, who compared the performance characteristics of an airplane driven by a gas turbine operating a jet and then a propeller. The final lecture was given by Prof. C. F. Taylor, a noted authority on internal-combustion engines, who outlined the problems involved in applying jet propulsion to aircraft. Each lecture was enthusiastically received by an attendance of more than 300 students and members of the faculty. The last meeting of the term was devoted to a dinner and general-get-together session, with entertainment provided by Prof. S. C. Simpson, an outstanding amateur magician.

Michigan State Reviews High Spots of Term Meetings

Dr. J. A. Strelzoff, assistant professor of electrical engineering, gave an interesting talk on "Dual Theory," at a joint meeting of the Michigan State College Branch and members of the A.I.E.E., A.S.C.E., and A.I.Ch.E., on March 7. By means of simple moment equations and the equations of Wheatstone's bridge, Dr. Strelzoff explained the fundamental process of using electrical circuits to solve problems of indeterminate statics. Prior to the meeting, members elected new officers as follows: R. G. Oonk, president; J. F. Peyton, vice-president; W. E. Miller, treasurer; T. H. Mitzelfeld, secretary; and W. S. Coleman, council representative. This Branch held another joint meeting on April 11, to hear A. G. Mather of Doall Midwest Company, explain gage blocks and precision instruments produced by his firm. Mr. Mather illustrated his talk with slides. At the April 24 meeting, members heard a report of the A.S.M.E. Conference held in the Rackham Memorial Building, Detroit, at which M. H. Lill presented a paper, "Problems of Rocket Design," which took first place in the Group VII contest. After a luncheon, the group went on an inspection tour of the Carboloy plant in Detroit. The evening session was devoted to a lecture by Dr. C. W. Chamberlien, retired professor of physics, who described his invention of intermolecular shock absorbers which are used to cushion vibration in engines on large warships and on foundations of forge hammers. On May 5, this Branch went on an inspection tour of the Olds plant, Lansing Mich., and on June 1, final meeting of the spring quarter, motion pictures featured the evening. The films shown were, "Fortress of the Sky," "Panama Canal," and several sport pictures.

Nebraska Branch started its annual membership drive at the June 20 meeting. Although the membership of this Branch is small, six old members were reported to have signed up for next fall.

A résumé of activities of the New Mexico Branch for the past year was reported by A. M. Lukens, head of the department of mechanical engineering. Mr. Lukens stated that since November, at least two meetings have been held each month, as well as a few joint meetings with the A.I.E.E., and that alumni members, businessmen, and authorities from the Farm Labor Bureau were guest speakers during this period. He also announced that five students and faculty representatives attended the student conference held at Texas University, Austin, Tex. He listed the following officers for the term: President, Joe Budenholzer; vice-president, Pete Privitz; secretary, Eugene Parks; and treasurer, Chester Rowland.

At the smoker of the New York University Branch (Day), held on June 12, an interesting illustrated talk on the materials used in the construction of the aircraft internal-combustion engine was given by H. Hannik, assistant chief of materials testing of the Wright Aeronautical Corporation. Mr. Hannik demonstrated the wide use of high-alloy steels in aircraft engines, their easy reproducibility and absence of internal strains ordinarily caused by heat-treating.

Northeastern Branch met on June 22 for the main purpose of electing new officers. The officers elected are: Serafin Krukonis, chairman; John H. Cowles, vice-chairman; Arthur L. Chase, secretary; Orin A. Smith, treasurer; Frederic D. McAllister, program committee chairman; Robert C. Twombly, social committee chairman; and Thomas Chin, publicity committee chairman.

The first meeting of the Ohio State Branch on June 16 was devoted to a series of discussions covering the types of programs desired by the members during the forthcoming semester, after which Professor Marco explained the many opportunities open to student members by continued membership in the A.S.M.E. after graduation.

Review of Oregon Activities

A. S. Hughes, honorary chairman of the Oregon Branch, recently submitted a résumé of the term's activities, beginning with the January 28 meeting up to and including June 11. At the January 28 session it was decided that two or more student members give short talks at each regular meeting. Members enjoyed numerous motion pictures throughout the term, heard prominent speakers, and went on various inspection tours, among the high spots of which were several two-day trips. The group left on the morning of March 25 for McMinnville, Ore., where the municipal Diesel-electric power plant was inspected. At noon the station L of the Portland General Electric Company was visited, and at 2:30 a trip was made through the Vancouver shipyard of the Kaiser Company. In the evening the group met with the Oregon Section, A.S.M.E., for dinner at the Portland Hotel, which was followed by a joint meeting in the Green Room at which four prize-winning student papers were presented. The night was spent at the George White Service Men's Center, and the next day a thorough inspection of the equipment at the Bonneville Dam and the powerhouse was made. On June 10, thirty-one members and guests inspected the C. D. Johnson Lumber Company Saw Mill and Prefabricated Building Department at Toledo, Ore., as well as the Yaquina Bay Fish Company plant at Newport, Ore. The group remained in Army barracks, east of Newport, for the night, and devoted the next

MICHIGAN STATE STUDENT BRANCH ON TOUR OF OLDS PLANT, LANSING, MICH.

IN ATTENDANCE AT THE 1944 STUDENT GROUP CONFERENCE, UNIVERSITY OF TEXAS, MAY 1, 1944

day to fishing and enjoying a short ocean trip in United States Coast Guard cutters.

Local Honors Presented at Pennsylvania

Due to the fact that the Group IV annual meeting of the A.S.M.E. Student Branches was canceled within less than a week's notice, PENNSYLVANIA BRANCH held a local contest on May 5, so that the work of nine students expended on the preparation of papers was not in vain. Prizes were awarded and three papers accepted as follows: "Air Flow at Supersonic Velocities," first prize, presented by P. O. O'Neill, and assisted by R. B. Watrous and D. A. Nelson; "The Flight of Rocket-Propelled Projectiles," second prize, presented by S. B. Ladd, and assisted by T. B. Wilson; "Silver-Solder Penetration in Brass Joints," honorable mention, presented by R. F. Tighe, and assisted by N. H. Hammond, D. D. James, and R. C. Ridings. The same evening a certificate of merit was awarded to Robert Watrous, student chairman, for outstanding achievement in forwarding the A.S.M.E. at the University of Pennsylvania. Members and guests of this Branch met on June 14, for their last meeting of the semester, to see two interesting motion pictures, "Railroadin," and "Television," lent through the courtesy of General Electric Company, Schenectady, N. Y. The guest of honor was Lee N. Gulick, chairman of the Philadelphia Section of the A.S.M.E. At a brief business meeting earlier the same evening, Thomas Wilson was elected vice-chairman.

Mathematical Solutions of Ballistic Problems Demonstrated at Purdue

Prof. G. A. Bliss, a retired member of the University of Chicago faculty, spoke on the application of mathematics to the solution of problems in ballistics, at a joint meeting of PURDUE BRANCH and the Department of Mathematics on May 31. Accurate range determinations of projectiles under various conditions involve many complicated mathematical equations. Professor Bliss explained briefly the derivation of some of these equations and discussed in some detail a mechanical integrating device which has greatly simplified the solution of these equations. This Branch featured Roy Sanford, well-known consulting engineer and inventor, as guest speaker at its June 14 meeting. Mr. Sanford, who has been granted approximately 250 patents, related some of his experiences in the field of invention. He told of his work on the four-wheel brake and of the many problems encountered before the first successful four-wheel brakes were produced. An open discussion followed Mr. Sanford's remarks, after which the following officers were elected: R. C. Hupp, chairman; R. D. Abelson, O. E. Flint, W. Barber, vice-chairmen; Paul Kolthoff, secretary-treasurer, and Prof. R. W. Leutwiler, honorary chairman.

Tracing the history of economic depressions of the past, J. O. Amstuz, chief engineer of Behr-Manning Corporation, Troy, N. Y., told members of RENSSELAER BRANCH on May 28, that engineering will play an important part in the postwar world. He pointed out that there would be tremendous advances in the aviation and automobile fields, and predicted that production of planes, automobiles, and many forms of consumer goods would be quadrupled.

"Quality Control in Manufacturing" Features Latest Rice Meeting

On April 12, members of RICE BRANCH discussed plans for the contemplated meeting, at the University of Texas, of the Southwest Student Branches of Section XIV, after which the following officers for the new term were elected: J. B. T. Downs, honorary chairman; William M. Black, chairman; James H. Elder, Jr., secretary, and Edward S. Beaty, treasurer. Members met again on May 21, to hear W. M. Black, presiding officer, give a report of the state meeting that was attended by six members of this Branch, and to view a lengthy film on the manufacture of wrought iron and wrought-iron pipe, presented through the courtesy of A. M. Byers Company, Pittsburgh, Pa. On June 8, the secretary of this Branch reported that the South Texas Section of the A.S.M.E. met on June 1, in South American Room A of the Rice Hotel in Houston. Prof. V. M. Faires, head, Management Engineering Department, Texas A.&M. College, was the guest of honor and spoke on "Quality Control in Manufacturing." Professor Faires reviewed the history of quality control and explained in detail how control charts worked and the use of the normal distribution curve. He explained how to eliminate guesswork in sampling and illustrated his points with actual control charts on representative parts.

War Films Feature Recent Meetings at Southern California

A motion picture entitled, "Battle for the Beaches," depicting landing barges in invasion, featured the May 25 meeting of the UNIVERSITY OF SOUTHERN CALIFORNIA BRANCH. S. C. Allen, secretary of this Branch, reported that motion pictures had also featured two previous meetings of this Branch. At one meeting, a United States Navy film depicted actual scenes of the early pioneer aircraft, development of aircraft-carrier landing facilities, experiments with lighter-than-air craft, development of dive bombing, and action shots of modern navy aircraft. Two films were viewed at the second meeting—an Office of War Information film, "Submarines at Sea," and a United States Navy film, "Full Speed Ahead." Both films are restricted to members of societies in engineering colleges. This Branch met again on June 7 to hear Professor Eyre, head of the Department of Mechanical Engineering, relate his experiences in the first world war. On June 14, members elected new officers as follows: Chairman, Charles Carper; vice-chairman, Bob Morton; secretary, John Nash; and treasurer, Shirli Allen.

Officers elected at the May 24 meeting of the WISCONSIN BRANCH are as follows: President, Melvin Diels; vice-president, Ralph Williams; secretary, Paul Kaesberg; local and S.A.E. treasurer, John Kaeting, and A.S.M.E. treasurer, Bill Wendt. After the election of officers, an interesting presentation of their Diesel research experiment was given by Messrs. Myers, Fiercisin, and Oyeharro.

The Gas Turbine in Transportation at Worcester Branch

The WORCESTER BRANCH held its annual meeting on May 23, at Putnam and Thurstons' Restaurant in Worcester, Mass. The speaker of

the evening was Dr. C. Richard Soderberg, who gave an intesting presentation of "The Gas Turbine and Its Application to the Transportation Field." At the business session of this meeting new officers were elected and are as follows: Frederick W. Mierke, chairman; Eric Smith, vice-chairman; and Carroll C. Tucker, secretary-treasurer. At the same time a gold medal was awarded to Prof. Carleton A. Read, Professor Emeritus of Worcester Polytechnic Institute, in commemoration of 50 years' membership.

Four speakers featured the June 6 meeting of YALE BRANCH, as follows: G. A. Gertz, who spoke on "Engineering Geology;" W. O. Blattner, "Engineering Education for What?;" A. J. Zikaras, "Early Indian Festivals," and H. D. Willis, "Hardwood Lumber."

Engineering Societies Personnel Service, Inc.

These items are from information furnished by the Engineering Societies Personnel Service, Inc., which is under the joint management of the national societies of Civil, Electrical, Mechanical, and Mining and Metallurgical Engineers. This Service is available to members and is operated on a co-operative, nonprofit basis. In applying for positions advertised by the Service, the applicant agrees, if actually placed in a position through the Service as a result of an advertisement, to pay a placement fee in accordance with the rates as listed by the Service. These rates have been established in order to maintain an efficient, nonprofit personnel service and are available upon request. This also applies to registrants whose notices are placed in these columns. All replies should be addressed to the key numbers indicated and mailed to the New York office. When making application for a position include six cents in stamps for forwarding application to the employer and for returning when necessary. A weekly bulletin of engineering positions open is available to members of the co-operating societies at a subscription of $3 per quarter or $10 per annum, payable in advance.

New York	Boston, Mass.	Chicago	Detroit	San Francisco
8 West 40th St.	4 Park St.	211 West Wacker Drive	109 Farnsworth Ave.	57 Post Street

MEN AVAILABLE[1]

WORKS MANAGER, heavy industry, machine shops, plate and sheet shops, iron and steel foundries. Up to 3000 people. Graduate mechanical engineer, 46. Me-850.

INDUSTRIAL ENGINEER OR STAFF EXECUTIVE, 29, graduate mechanical engineer with 8 years' manufacturing experience including wage incentive, job analysis,standard practice instructions, training, methods, and manufacturing controls. Industries include aircraft, sewing machines, steel mill, conveying equipment. Draft-deferred. Prefer West Coast. Me-851-446D5 San Francisco.

GRADUATE MECHANICAL ENGINEER, 20 years' experience, 12 of which in executive position, in Diesel engines (large and small), steam engines, reciprocating pumps (hot oil, slush, and hydraulic) and hydraulic systems. Desires connection with postwar future in general engineering supervision as top executive with small concern or as assistant to executive with large concern. East preferred. Me-852.

MECHANICAL ENGINEER, 35, with creative and executive ability; experienced in supervision of design, production, plant layout, maintenance, estimates, closing contracts of light and heavy products. Desires position as chief engineer. Me-853.

[1] All men listed hold some form of A.S.M.E. membership.

POSITIONS AVAILABLE

MECHANICAL ENGINEER with chemical and industrial experience as supervisor in maintenance of machinery and equipment in local plant manufacturing pharmaceuticals and light chemicals. Salary open, depending upon age, education, and experience. New York, N. Y. W-3929.

PLANT MANAGER, 30–40, graduate or equivalent, chemical engineering background desirable; also training in industrial engineering, experience in modern manufacturing methods and controls, and plant layout, etc. Company well-known, long established, industrial organization manufacturing an extensive line of packaged goods including household and toilet necessities. Will work with industrial-engineering department in the selection of a site for, and in guiding design and layout of, an entirely new plant which will represent the last word in modern machinery, equipment, and methods; and to manage this new plant upon its completion. Salary open. W-3943.

MECHANICAL ENGINEER as plant superintendent of Diesel engine power station in South America. $4200 year. W-3955.

ASSISTANT TO FACTORY MANAGER for small company manufacturing equipment for industrial air conditioning. Largely sheet-metal work. About $5000 a year. Georgia. W-3960.

INDUSTRIAL ENGINEER, young; strong on methods and standards side of manufacturing costs; very personable. $5200–$6000 a year. W-3963.

ASSISTANT TO WORKS MANAGER capable of handling 800 to 1000 employees for large machine-tool and tool-manufacturing concern. Massachusetts. W-3967B.

INDUSTRIAL ENGINEER for methods and time study in light-metals foundry. $5000–$7500 a year. Maryland. W-3979.

DESIGNER, 35–40, for automatic paper machinery with experience in designing and laying out equipment. $5000 a year. Permanent with excellent postwar opportunity. New York, N. Y. W-3980.

INDUSTRIAL ENGINEER with wide experience to supervise general staff in field and office. $6000 a year plus bonus. Headquarters, New York, N. Y. W-3993.

CONSULTANT to give advice of port and terminal facilities and charges. Advice will be needed on correlating railroad and shipping facilities, freight-handling methods and shipping facilities, warehouse and terminal requirements and operation, freight rates and traffic, discharging and loading charges, wharfage and handling, and storage charges, etc. Connecticut. W-4001.

ENGINEERS. (*a*) Mechanical designer and development engineer for helicopter work. Need not have this experience, but should have some background in aeronautics. $4500 a year. New York, N. Y. (*b*) Also chief designer for similar work on the West Coast. Salary open. W-4014.

CHIEF ENGINEER in power plant. Prefer graduate mechanical engineer. Should have 6 to 10 years in power-plant construction or operation. Co-operativeness and good record in handling people necessary. $4000 a year. Michigan. W-4019-C.

ENGINEERS, preferably young, but will consider older men, for servicing, installing, and testing filtration equipment. Experience in the filtration line desirable but not essential. After training this position will lead to that of sales engineer. Salary open, depending upon

Diesel Engineering Laboratories Dedicated at North Carolina

A DIESEL engineering laboratories building was dedicated recently at the North Carolina State College. Diesel engineering courses began at North Carolina State College on Jan. 6, 1941, and developed such high value that they were incorporated in the training program of the U. S. Navy. On March 31, 1941, the first class of naval officers reported to the director of the Engineering Defense Training courses, which proved so successful that the Navy decided to move in. The complement of officers was expanded fifteenfold under the constant guidance of Captain A. S. Adams and Lieutenant Commander W. K. Thompson, in Washington, and Lieutenant Commander John H. Smith in Raleigh. A suitable building for housing this joint Navy-State College project was erected with money allocated from the state's Emergency Fund by the Governor of North Carolina. The Bureau of Ships provided engines and erected them in the building as installed on the ships. Among those who assisted on the dedication program were Frank P. Graham, president of the college; Rear Admiral E. L. Cochrane, U.S.N.; George W. Codrington, member A.S.M.E.; Col. J. W. Harrelson; Acting Dean L. L. Vaughan, member A.S.M.E.; Prof. Robert B. Rice, member A.S.M.E.; Lieutenant Commander John Smith, U.S.N.; and Honorable J. M. Broughton, Governor of North Carolina.

R. P. Reece and Robert B. Rice represented The American Society of Mechanical Engineers at the dedication ceremonies.

experience, etc. Headquarters, New York, N. Y., with territory on eastern seaboard to Cleveland. W-4029.

EXECUTIVE-MAINTENANCE ENGINEER. Should have some experience in bakery industry for large national bakery operations. $4500 a year. Central Middle West. Interviews, New York, N. Y. W-4030.

MANAGER to head up development and design department, 35–45, graduate mechanical or electrical, with some years' experience in actual design of instruments, machinery, or similar devices. Must be able to criticize designs and ideas of other engineers and help lay out and execute a development program. Will handle department of 10 or 12 engineers and designers, a test laboratory of 10 or 12 men, and will give suitable instructions to the model room. Knowledge of electronics helpful, but mainly should be engineering executive with mechanical-design experience. Connecticut. W-4031.

EXECUTIVE ENGINEER, 35–45, experienced, with mechanical and chemical background, preferably in plastics, but not necessary. Will have charge of research and product development in thermosetting plastics. $7500 a year or more. Good opportunity. Pennsylvania. W-4033.

TRAINING SPECIALIST, 30–50, graduate with specialization in marketing. Should have some experience in sales work and some in organizing and conducting training courses and projects for sales representatives. Should be familiar with educational methods and training aids. Should have ability to get along well with executives and supervisors. Base salary, $3600–$4200 a year, depending upon qualifications, plus overtime. Permanent. New Jersey. W-4042.

CHIEF ESTIMATOR with a practical knowledge of die designing and press work, and also ability in redesigning castings, forgings, etc., into stampings. Company is in jobbing-stamping business, producing stampings from ferrous and nonferrous materials. Massachusetts. W-4044-B.

ELECTRICAL OR MECHANICAL ENGINEERS, graduates, with about 10 years' experience in industry. Should have thorough knowledge of French and German. Will collect, screen, and evaluate industrial information. $4500–$5200 a year plus $6 a day living expenses plus traveling expenses. Foreign. W-4047.

Candidates for Membership and Transfer in the A.S.M.E.

THE application of each of the candidates listed below is to be voted on after August 25, 1944, provided no objection thereto is made before that date, and provided satisfactory replies have been received from the required number of references. Any member who has either comments or objections should write to the secretary of The American Society of Mechanical Engineers immediately.

KEY TO ABBREVIATIONS

Re = Re-election; Rt = Reinstatement; Rt & T = Reinstatement and Transfer to Member.

NEW APPLICATIONS

For Member, Associate, or Junior

ALEXANDER, PETER M., Hayward, Cal.
ANDREWS, PAUL, Meriden, Conn.
ANDREWS, RAYNAL W., JR., Pittsburgh, Pa. (Rt & T)
AVEDOVECH, MYER, Grand Island, Neb.
AVERY, WM. M., Chicago, Ill.
AYASUN, NURETTIN, Erbaa, Turkey
BILIMORIA, PHIROZE D., Poona, India
BLAND, FREDERICK V., JR., Elgin, Ill.
BOBNIO, CHAS. H., Bellmore, N. Y.
BRABETZ, EDWIN E., Peoria, Ill.
BRASKI, NEIL J., Painesville, Ohio
BROWN, G. S., Downer's Grove, Ill.
BUCKLEY, FRED D., New York, N. Y.
BYSTROM, JOHN H., Trenton, N. J.
COLLINS, DAVID M., Gulfport, Miss.
COSTELLO, F. T., JR., Utica, N. Y.
DAHLMAN, FRED A., Corning, N. Y.
DAVIDSON, DAVID J., Pittsburgh, Pa.
DECKER, HERBERT R., Decatur, Ill.
DODSON, WESTON, Arlington, Va.
DOWNS, EUGENE L. Chicago, Ill.
EARLE, CHESTER R., Chicago, Ill.
FAIRCHILD, O., Brooklyn, N. Y.
FOSTER, TILLMAN R., New York, N. Y.
FYFE, JOHN H., Drexel Hill, Pa.
GALUZEVSKI, ROSTISLAV A., Ann Arbor, Mich.
GARY, H. H., Norfolk, Va. (Rt)
GIGUERE, GEORGE H., Detroit, Mich.
GORDER, C. G., Chicago, Ill.
GREEN, WALTER F., Canton, Ohio
HASSELBERG, FREDK. C., JR., Coatesville, Pa.
HASWELL, HENRY L., Brevard, N. C.
HAUGER, HARRY H., JR., Los Angeles, Calif.
HESS, RAYMOND W., Glenolden, Pa.
HEWITT, ELLIS E., Wilmerding, Pa.
HINKLEY, RAY A. Corning, N. Y.
JOHNSON, V. E., Milwaukee, Wis. (Rt & T)
KAMDAR, H. M., Bhavnagar, Kathiawar, India
KNECHT, A. WILSON, Yonkers, N. Y.
KRAMER, WM. H., JR., Phillipsburg, N. J.
KRIGER, RALPH S., Corning, N. Y.
KILKA, SIEGMUND, Detroit, Mich.
KUNZ, WARREN, Manchester, Conn.
LAKE, EUGENE T., Cranford, N. J.
LAMING, W. E., San Francisco, Calif.
LAND, GEORGE W., Earlington, Ky.
LEE, HAROLD C., New Orleans, La.
LEWIS, ROBT. B., Chicago, Ill.
LEHMBERG, WM. H., Glenville, Conn.
LOMONOSSOFF, BORIS, Washington, D. C.
MCCONNELL, M. F., Pittsburgh, Pa. (Rt)
MCGINNIS, DAVID M., Los Angeles, Calif.
MCMURRICH, ROBT. P., Melbourne, Victoria, Australia
MEINERS, RICHARD H., Wauwatosa, Wis.
MICHENER, WM. E., Milwaukee, Wis.
NOWACKI, LEO M., Schenectady, N. Y.
OHLER, RALPH E., Waterloo, Iowa (Rt & T)
ORR, WESLEY L., Santa Monica, Calif.
PARKER, MILTON E., Barrington, Ill.
PENN, W. H., Brunswick, Ga.
POLIVKA, JARO J., Berkeley, Calif.
POND, L. N., Corning, N. Y.
PROSSER, ROBT., G., Washington, D. C.
RAMSAY, ERSKINE, Birmingham, Ala. (Rt)
RICE, WM. M., Tulsa, Okla.
ROSS, RICHARD H., Williamsport, Pa.
RYAN, JOHN T., JR., Pittsburgh, Pa.
SCUDDER, CHAS. M., Wauwatosa, Wis.
SMITH, HERMAN E., JR. (Capt.), Oklahoma City, Okla. (Re)
SMITH, HARRY G., Pasadena, Calif.
SQUIRES, V. G., Antioch, Calif.
STEARNS, WALTER J., Rumford, Maine
STEVENS, ROY R., Pittsburgh, Pa.
STUTSKE, WM. A., Corning, N. Y.
TAGGART, JAS. M., Huntington, N. Y.
THOMAS, THOMAS N., Canton, Ohio
UNDERWOOD, C. M., Minneapolis, Minn.
VON ARB, EDW. J., Evansville, Ind.
WELLECH, EDMUND H., Corning, N. Y.
WHEELER, R. C., Baltimore, Md. (Re)
WILLIAMS, ALLAN J., JR., Tonawanda, N. Y.
WILLIAMSON, W. R., Chicago, Ill. (Rt)
WOOD, FREDRIC E., Oak Park, Ill.
WOODHOUSE, ROBT. J., New York, N. Y. (Rt)
WORTERS, C. R., Chicago, Ill.
ZWISSLER, LEWIS E., Greensburg, Pa.

CHANGE OF GRADING

Transfer to Fellow

MCKEE, NEAL T., Bronxville, N. Y.

Transfers to Member

BABIKIAN, H. M., Alexandria, Egypt
BOLLES, SIDNEY L., Queens Village, N. Y.
DAVIS, EDMUND C., Baltimore, Md.
ESCHER, W. F., Detroit, Mich.
KOHL, FREDK. S. (MAJ.) ,Watertown, Mass.
LEETE, WM. T., Hartford, Conn.
PERRIN, ARTHUR M., Brooklyn, N. Y.
TAYLOR, RICHARD M., Baltimore, Md.
VAN SCHWARTZ, ZOLLY C., Akron, Ohio
WHEELOCK, BENNETT R., JR., Wyandotte, Mich.

A.S.M.E. Transactions for July, 1944

THE July, 1944, issue of the Transactions of the A.S.M.E. contains:

Maintenance of Hydroelectric Generating Units, by G. H. Bragg
Development of the Lysholm-Smith Torque Converter, by A. Lysholm
Gas Turbines and Turbosuperchargers, by S. A. Moss
Bursting Tests of Steam-Turbine Disk Wheels, by E. L. Robinson
Fluid Flow Through Two Orifices in Series—II, by M. C. Stuart and D. R. Yarnall
The Combustion of Barley Anthracite, by A. J. Johnson
New Combustion-Control Methods for All Standard Fuels, by Robert Reed
Investigation of Blade Characteristics, by J. R. Weske
Notch-Toughness Tests of Carbon-Molybdenum Pipe Material, by W. F. Kinney, I. A. Rohrig, and H. S. Walker
Firing High-Pressure Furnaces, by E. G. Peterson
"Temp-turb" Temperature-Control System, by J. R. Campbell
Fatigue Studies on Urea Assembly Adhesives, by A. G. H. Dietz and Henry Grinsfelder
Heat and Vapor Transfer in the Dehydration of Prunes, by R. L. Perry
A New Approach to the Problem of Conditioning Water for Steam Generation, by R. E. Hall